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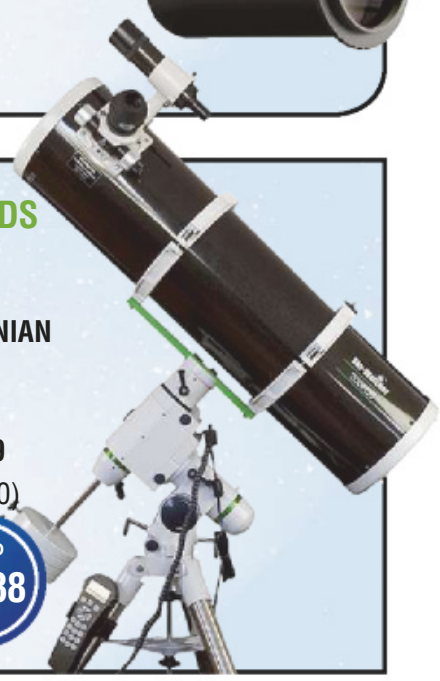

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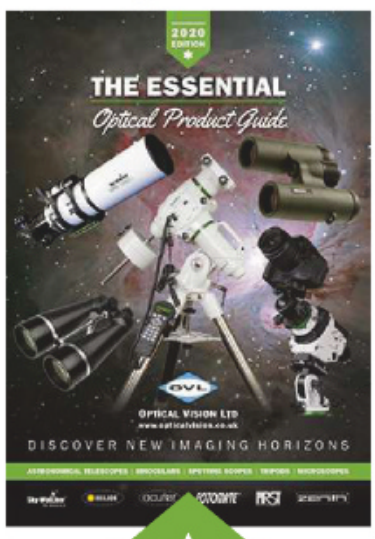

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NGC7635 image by Gordon Haynes www.imagingtheheavens.co.uk

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- 10th June - Moonday in Regent's Park with Eric Emms & the BSIA
- 15th June - Webb Society, Cambs
- 23rd June - Central London SUNday in Regents Park
- 20th July - Solar/ Open Day + Apollo 50th Anniversary Moonwatch
- 27th July - Cambridge Rock Festival
- 10th August - SAC Astrofair, Devon
- 27-29th September - Equinox Star Party, Kelling Heath, Norfolk
- 15-16th Nov - IAS Warwickshire

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**Occasionally we will be closed on Saturdays for major events such as Star Parties, International Astronomy Show etc*

Welcome

Start stargazing now – with our 10-step easy guide

With Christmas over, getting to know the night sky better is the perfect way to fill the dark early evenings. There's a whole galaxy of sights out there for families to discover, and our special issue this month is here to help! So wrap up warm and turn to Stuart Atkinson's 10-step easy guide to get you stargazing, starting on page 30. And for more astro advice, remember that you can also watch the latest *Sky at Night* episode on BBC iPlayer, 'A beginner's guide'.

There's no equipment necessary to start a journey that'll expand your view of nature, but if you do feel the urge to get up close to the stars, take a look at page 86, where we review six great starter scopes for under £100. There are tabletop scopes for the youngest stargazers, as well as sturdy tube and tripod type setups for older kids and teens.

On top of a tripod sits perhaps the most unsung accessory in stargazing – the mount. This bit of kit, which holds a scope steady and makes it possible to move between sights, is crucial to your enjoyment of observing the night sky. On page 67 amateur astronomer Will Gater has some advice for choosing and using one, which will have you zooming straight in on what you want to see with a minimum of knob-twiddling.

Lastly, this issue we celebrate the 90th anniversary of a great moment in amateur astronomy – Clyde Tombaugh's discovery of Pluto. The midwest American farmboy's sketches of the planets brought him to the attention of the Lowell Observatory, where he painstakingly identified the Solar System's former ninth planet. Read the fascinating story on page 72.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on 20 February.

HOW TO CONTACT US

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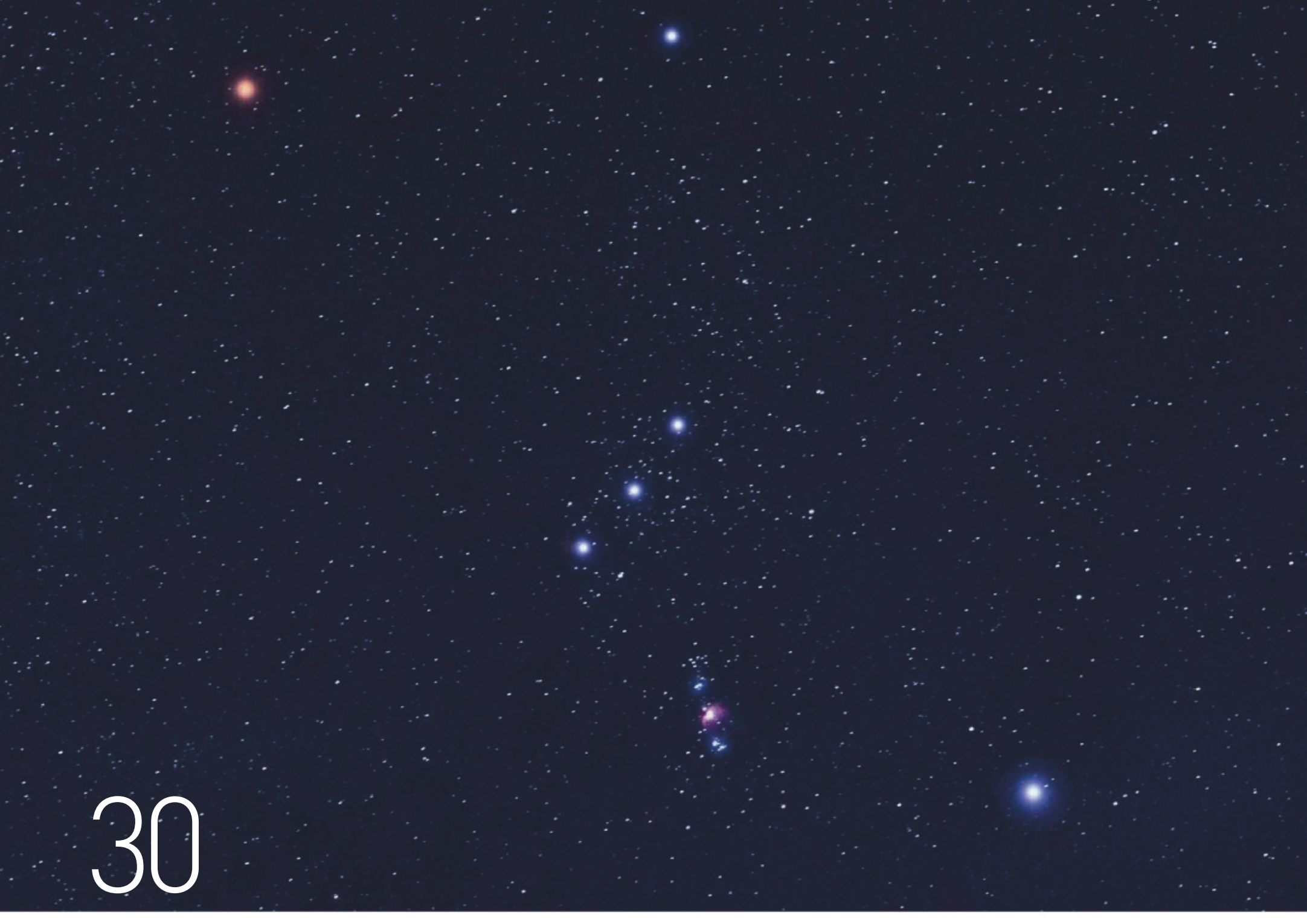

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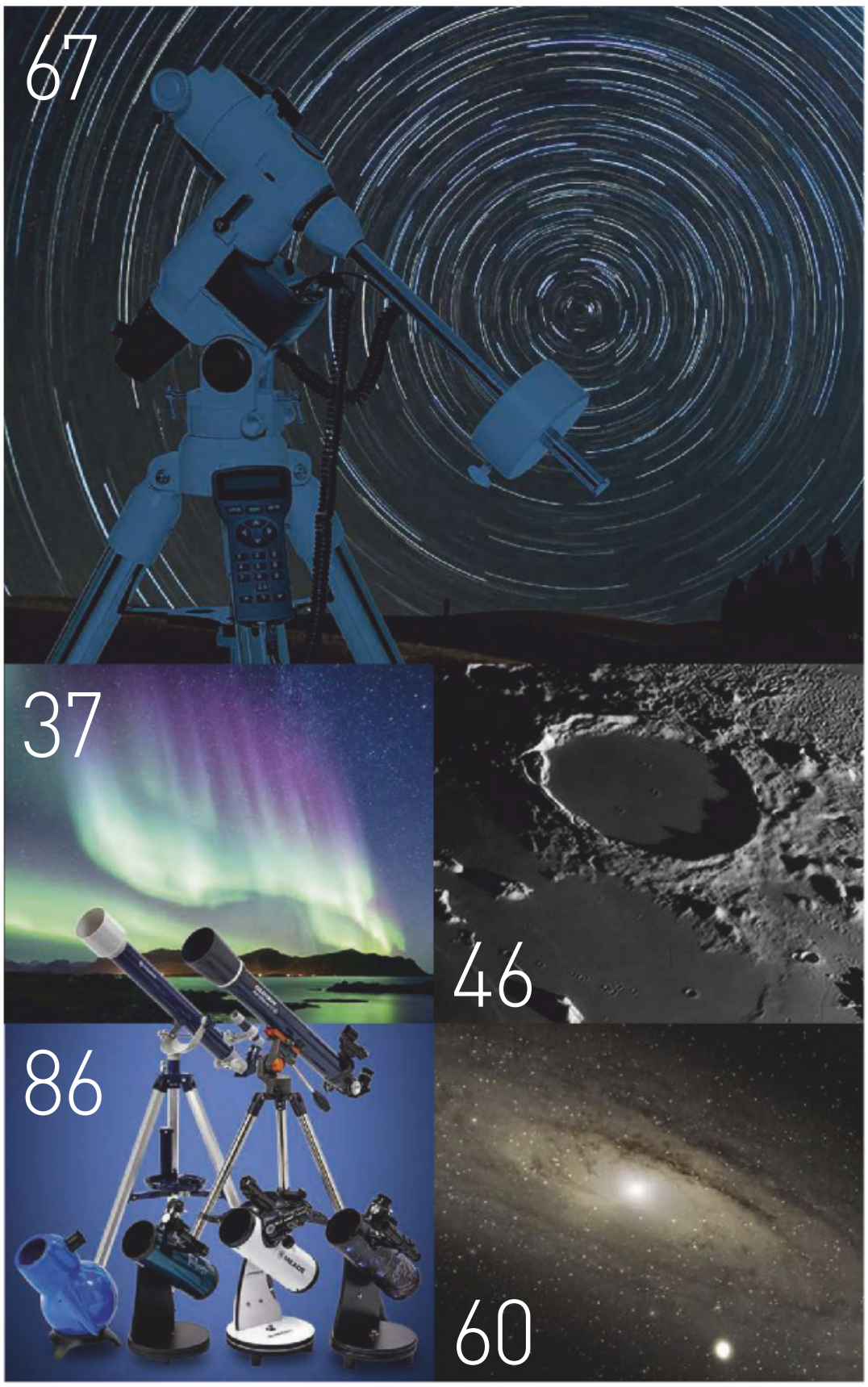
New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**



This month's contributors

Melanie Windridge

Plasma physicist

Melanie explains why the the aurora produces such a spectacular array of colours. See page 37.

Charlotte Daniels

Astronomer and journalist

Charlotte compares images captured under different levels of light pollution. See page 60.

Will Gater

Astrophotographer

What telescope mount is best for your setup? Will considers the options. Turn to page 67.

Stuart Atkinson

Amateur astronomer and author

You don't need to spend loads of money to go stargazing. Stuart gets back to basics on page 30.

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/F9L65BA/** to access this month's selection of exclusive Bonus Content.

FEBRUARY HIGHLIGHTS

The Sky at Night: 2019 review

Chris and Maggie look back on the biggest space missions and cosmic discoveries of last year.

Interview: launching the first GPS satellites

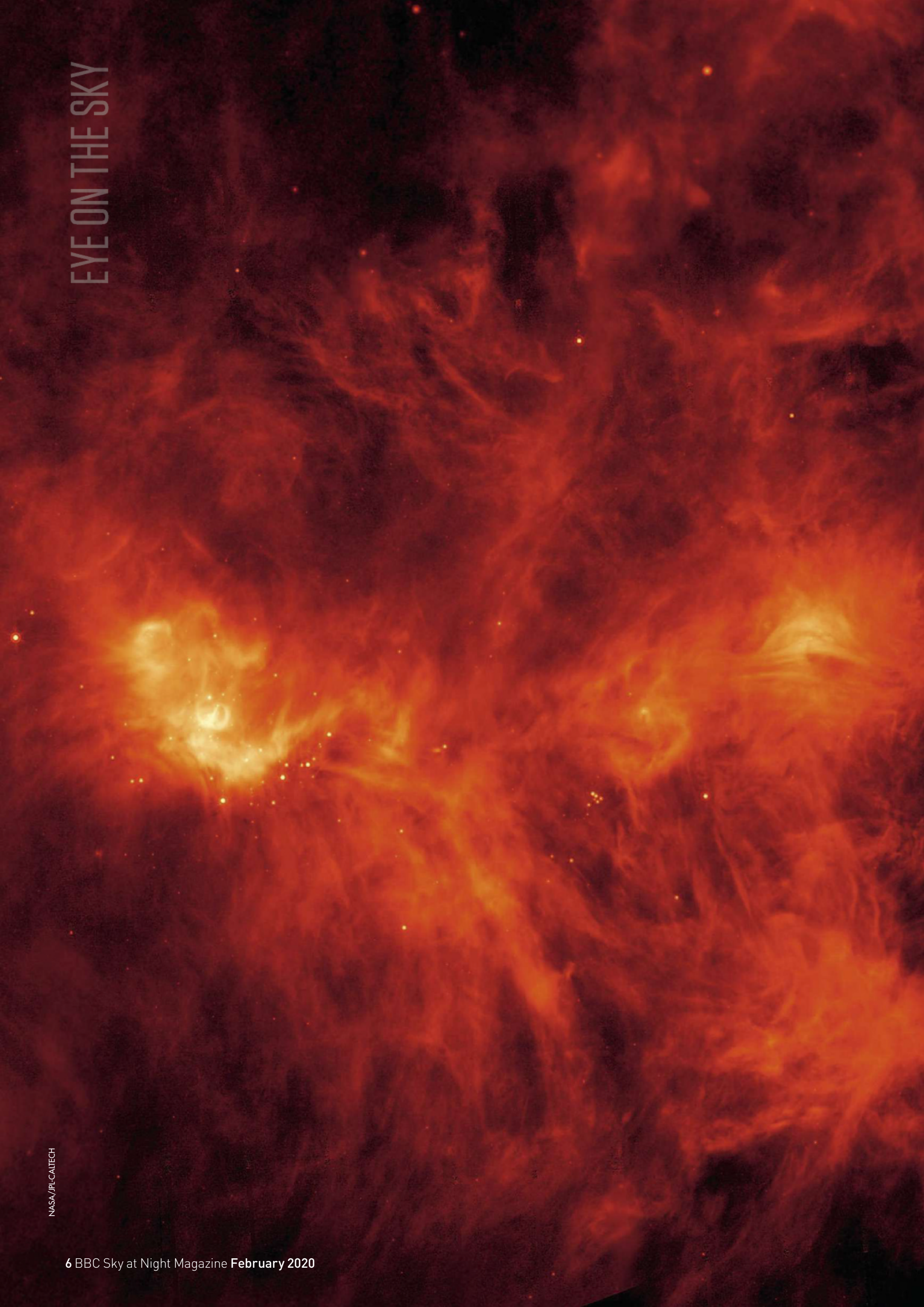
GPS architect Dr Brad Parkinson talks Sputnik, space junk, satellite orbits and whether GPS could work on Mars.

Audiobook: When The Earth Had Two Moons

Listen to chapters from a new book revealing the explosive and chaotic origins of our Solar System and life on Earth.

The Virtual Planetarium returns!

Watch our new and improved interactive guide to the month's night-sky highlights, with Pete and Paul.



NASA/JPL-CALTECH

In the RED

The Perseus Molecular Cloud glows in infrared in one of the last images to be released by the Spitzer mission

SPITZER SPACE TELESCOPE, 19 DECEMBER 2019

Near the left foot of the constellation of Perseus, the 500 lightyear-wide Perseus Molecular Cloud is an enigmatic region of the sky. Containing over 10,000 solar masses of gas and dust but emitting little visible light, the objects in this immense cloud are stunningly revealed in these infrared images from NASA's Spitzer Space Telescope.

Recently released, the image was actually captured during the telescope's initial 'cold phase', from launch in 2003 until 2009, before its supply of liquid helium coolant ran out.

One of the nearest active sites of star formation within the solar neighbourhood at only 850 lightyears away, one of the Perseus Molecular Cloud's main features is the swirling 400-star cluster IC348 on the left of this image.

Spitzer retired in January this year, after 16 years of groundbreaking infrared observations of the Universe.

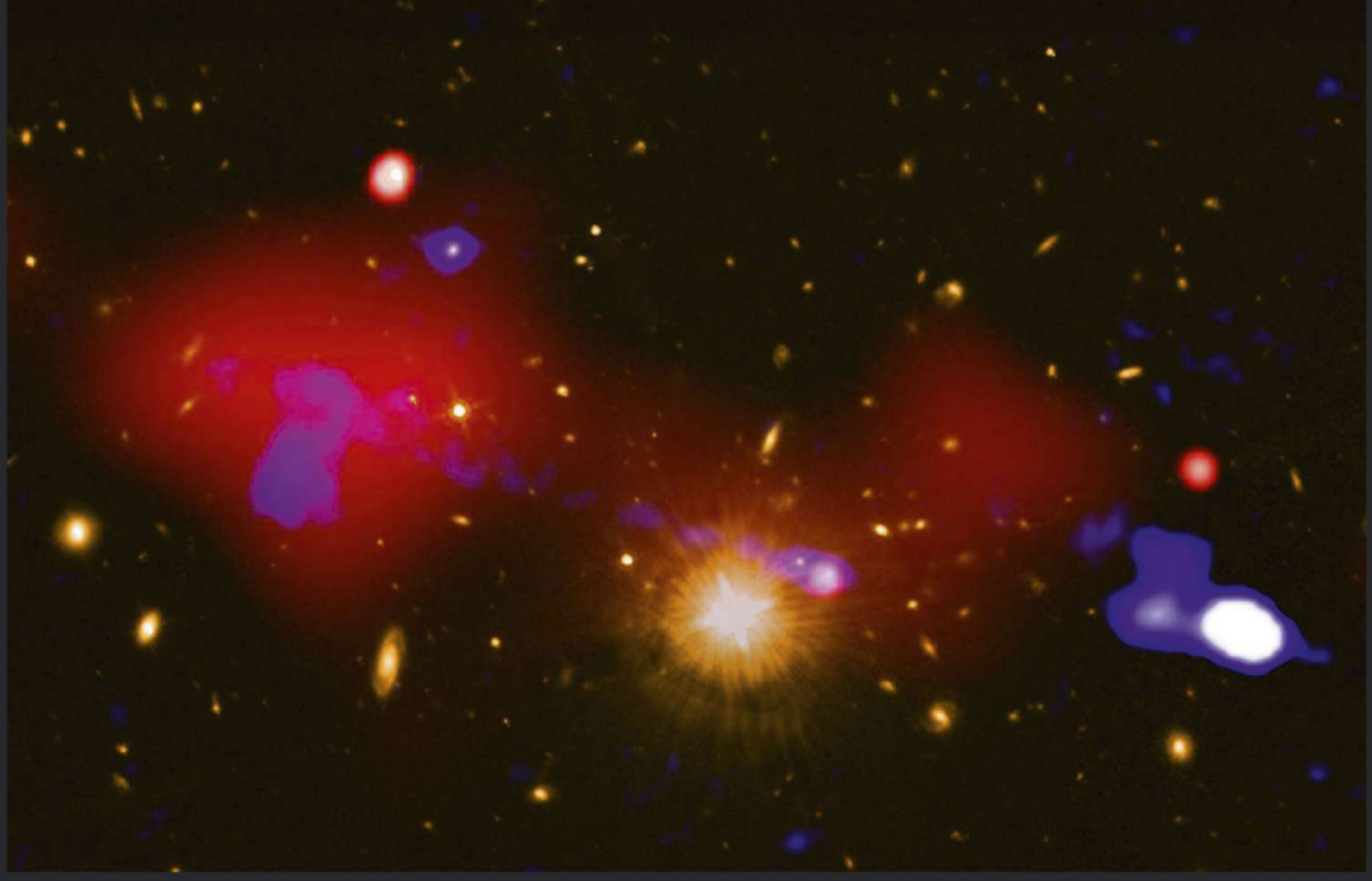
MORE ONLINE
A gallery of these and more stunning space images

△ Restless heart

HUBBLE SPACE TELESCOPE, 23 DECEMBER 2019

This serene image of spiral galaxy ESO 021-G004, 130 million lightyears away, belies the upheaval at its heart. The galaxy has an active nucleus, meaning that high levels of radiation are emitted from its centre, indicating that material is endlessly falling into the supermassive black hole at its core. The infalling material forms an accretion disc hotly swirling around until it is consumed, emitting X-rays, radio and ultraviolet radiation in the process.

ESA/HUBBLE & NASA/D. ROSARIO ET AL, ESO/NOGUERAS-LARA ET AL., X-RAY: NASA/CXC/INAF/R. GILLI ET AL.; RADIO NRAO/VLA; OPTICAL: NASA/STSCI, ESO/FARINA ET AL.; ALMA (ESO/NAOJ/NRAO), DECARLI ET AL.



▽ Billion-year baby boom

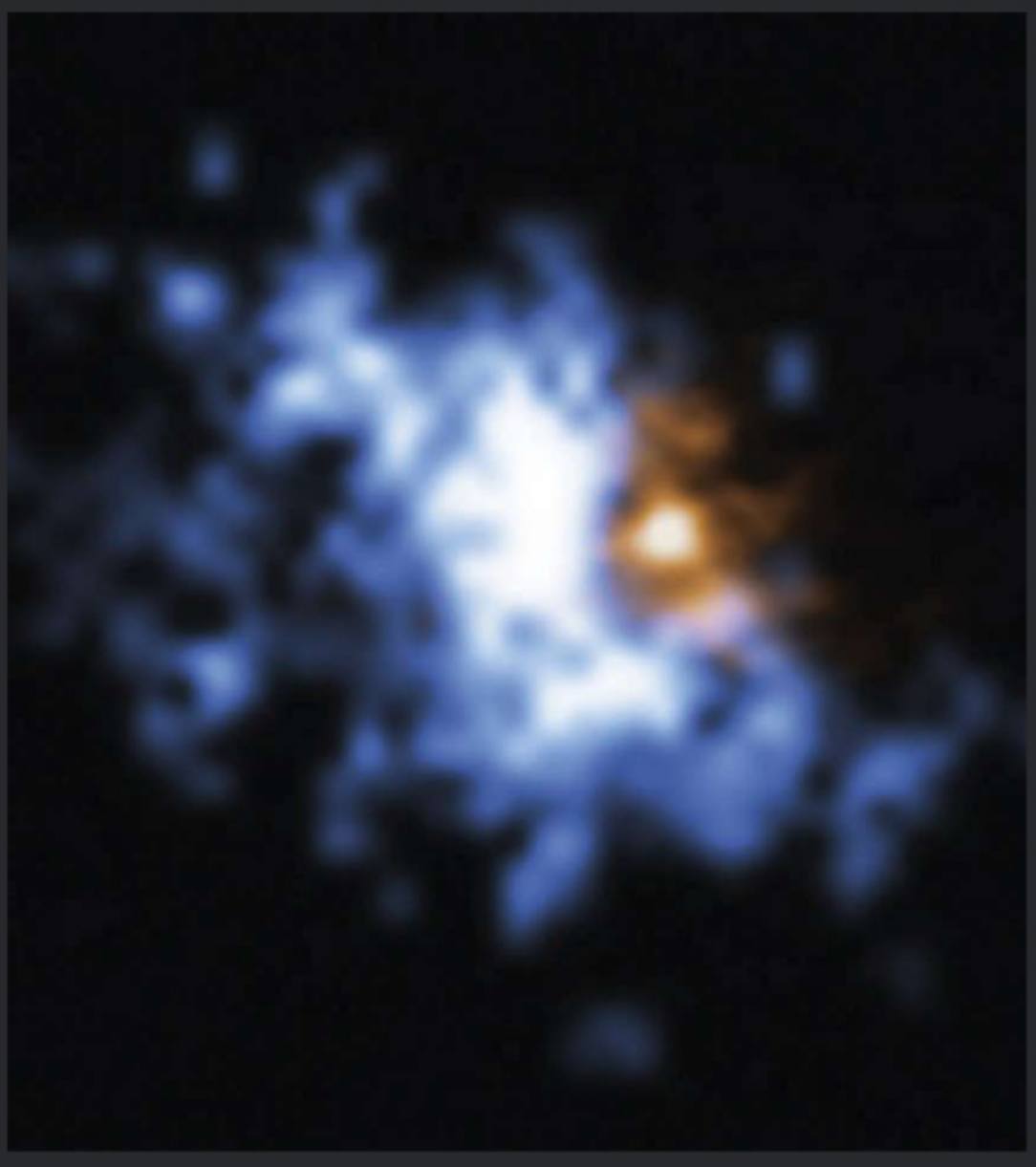
VERY LARGE TELESCOPE, 16 DECEMBER 2019

A violent but prolific period of star making has been revealed in this image by VLT's near-infrared HAWK-I instrument. Around 1,000 lightyears across, this super-dense region of the central Milky Way, teeming with stars, gas and dust, represents a period one billion years ago when, following several billion years of relative dormancy, millions of suns were formed in our Galaxy and 100,000 supernovae exploded.

△ Black hole boost

CHANDRA X-RAY OBSERVATORY, HUBBLE SPACE TELESCOPE, VERY LARGE ARRAY, 26 NOVEMBER 2019

Black holes are known for their deadly effect on star formation, but this image suggests they may sometimes boost star making. A composite of radio, optical and X-ray data, it shows a black hole within a host galaxy (the pink spot near the centre) around 9.9 billion lightyears away. A gigantic bubble of hot gas generated by the black hole is thought to have expanded and swept through four neighbouring galaxies, creating a shockwave that compressed cool gas, causing stars to form over one million lightyears away.



◁ Hydrogen halo

VERY LARGE TELESCOPE, ALMA, 19 DECEMBER 2019

How were primordial galaxies able to grow so fast? This image of a blue hydrogen halo swathing a quasar may hold the answer. Some quasars – ultra-bright objects powered by supermassive black holes at the centres of galaxies – have been shown to have a reservoir of cool surrounding gas, which would have fed supermassive black holes in the earliest galaxies, fuelling their growth and star formation.

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The latest astronomy and space news, written by Elizabeth Pearson

BULLETIN

NASA's OSIRIS-REx has discovered particles being ejected from asteroid Bennu, and inset, its rocky surface

Bang theory: is Betelgeuse, the bright reddish star (above left) in Orion, about to go supernova?

CONSTANTINCORNEL/ISTOCK/GETTY IMAGES

BETELGEUSE
is the dimmest it's been in a century

Astronomers are watching the star as it could become a supernova

Betelgeuse has dimmed to its lowest brightness since records began. The star, which makes up Orion's left shoulder, is a red supergiant and variable star which typically has a brightness between mag. +0.3 and +1.0.

"We noticed the star fading a few months ago – that's not so unusual. But it kept on fading, reaching mag. +1.21 around 8 December," says Edward Guinan from Villanova University. By 19 December, the star had dimmed to mag. +1.27.

Researchers at Villanova University have monitored Betelgeuse for the last 25 years, though the American Association of Variable Star Observers has records going back 100 years. Interest in Betelgeuse stems from the fact the star is approaching the end of its life.

"If it was at the Sun's position in the Solar System, Betelgeuse would extend out almost to Jupiter," says Guinan. "Now at an age of 8-9 million years, it's been estimated that Betelgeuse is on the verge of becoming a supernova anytime within the next million years."

Astronomers are monitoring the star to understand how red giants act just before going supernova. They've discovered Betelgeuse has multiple cycles of brightening, oscillating over different time scales. The least bright part of these patterns are currently lined up, which is probably the cause of the unusual low.

But, could the lull be a sign of something more sinister?

"No one is sure what to expect immediately prior to a supernova," says Guinan. "We do have a contingency plan for observing the star in the unlikely event that it does explode. We put out an alert to other astronomers so that additional observations can be made at this unusual time."

https://www.aavso.org/

Comment

by Chris Lintott

The dimming of Betelgeuse has excited astronomers, galvanised observers, and tantalised us with thoughts that the star might be about to go supernova. That remains unlikely, but I find myself marvelling at the show.

Orion looks odd right now. At its brightest, Betelgeuse can come close in brightness to Rigel, Orion's foot. It's not now in the same league and is fainter than Aldebaran in neighbouring Taurus. The star's red colour has faded too, though this may be an optical illusion; red stars seem less red when fainter.

No one alive has seen the sky look like this, and we don't know what Orion will look like in just a few weeks' time. I can't think of a better reason to pause and look up at January's skies.

New research is shedding light on our Galaxy's real age

MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY, UNIVERSITY OF WARWICK/ MARK GARLICK, SARAO,/NRAO/AUI/NSF, JONATHEN HARTY

The Milky Way's disc is 10 billion years old

The Galaxy's stellar ages can be measured by looking at their vibrations

The conundrum surrounding the age of the Milky Way's disc might have finally been solved, as a new analysis of data from the Kepler Space Telescope has set the age of the disc at around 10 billion years old.

The Milky Way has two discs: a thin disc and a thick extended one surrounding it. The thick disc is very sparse, with only 20 per cent of the number of stars found within the thin disc. The stellar population of the thick disc is predicted to be much older, but exactly how much older has been a long-running question.

"This finding clears up a mystery," says Sanjib Sharma from Australia's ASTRO 3D (ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions) who led the study. "Earlier data about the age distribution of stars in the disc didn't agree with the models constructed to describe it, but no one knew where the error lay in the data or the models. Now we're pretty sure we've found it."

Sharma's team measured stellar ages in the disc using asteroseismology, which looks for brightness fluctuations caused by starquakes.

"The quakes generate soundwaves inside the stars that make them ring or vibrate," says Dennis Stello from ASTRO 3D. "The frequencies produced tell us things about the stars' internal properties, including their age. It's a bit like identifying a violin as a Stradivarius by listening to the sound it makes."

Using this technique on Kepler data, the team initially measured the ages of the stars being much younger than models predicted, leaving the astronomers wondering where their error lay.

However in 2013, Kepler was reprogrammed to observe the sky in a different way, when it went into its K2 mission. During this time, the telescope observed patches of sky for 80 days at a time. This new deep observation allowed the ASTRO 3D team to analyse the chemical composition of the stars in a new level of detail. These differed from previous measurements, affecting the ages predicted by their computer simulations. When the team reran the models, the ages of the stars came out in close agreement with those obtained by asteroseismology.

https://astro3d.org.au/

▲ A hidden planet with a comet-like tail of gas has been revealed as it orbits a white dwarf

Giant planet found around white dwarf

The planet is four times the size of the star it orbits

A planet has been spotted in orbit around a white dwarf, the first time such a world has been seen. The find is unusual, as most planets are destroyed in the stage preceding a star becoming a white dwarf, when it balloons out to become a red giant.

It's thought the planet was originally further out but moved inward after its star's red giant phase ended, allowing it to survive. Once here, the star's 28,000°C temperature boiled away the planet's atmosphere. This created a huge cloud of gas and it was this which the astronomers detected.

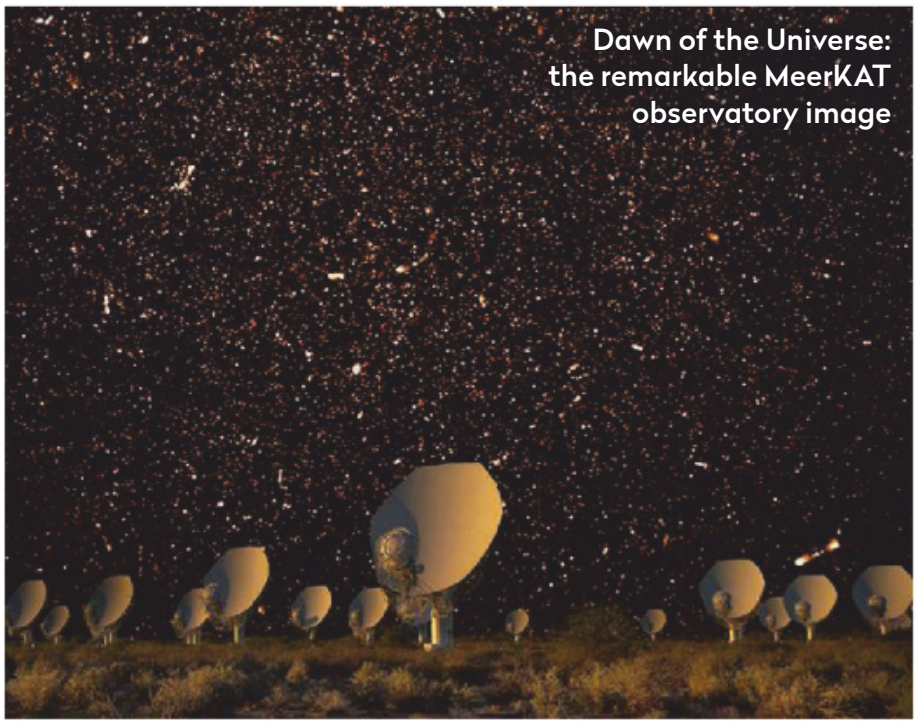
"This discovery is major progress because over the past two decades we had growing evidence that planetary systems survive into the white dwarf stage," says Boris Gaensicke from the University of Warwick, who led the study.

http://warwick.ac.uk

Star formation at 'cosmic noon' revealed

The first ever radio image of distant Milky Way-like galaxies has been taken by the MeerKAT observatory in South Africa. The image will help reveal how stars formed at the dawn of the Universe.

The images show galaxies that are so far away we're seeing them as they were 8 to 11 billion years ago. This era, known as the cosmic noon, is when most stars were born. These galaxies are usually obscured by clouds of dust, but MeerKAT looks at radio waves, which can pass through them.



Dawn of the Universe: the remarkable MeerKAT observatory image

"These first results indicate that the star-formation rate around cosmic noon is even higher than was originally expected," says Allison Matthews from the University of Virginia, who took part in the study. "Previous images could only detect the tip of the iceberg, the rare and luminous galaxies that produced only a small fraction of the stars in the Universe. What we see now is the complete picture: these faint dots are the galaxies that formed most of the stars in the Universe."

www.sarao.ac.za

NEWS IN BRIEF

Andrew Davies dies

Andrew Davies, a tireless ambassador for astronomy, died on 17 December 2019 in New Zealand. He was 57. His contribution to the community included lecturing, directing the Knowledge Observatory, founding the Mid-Cheshire Astro Group and the Runcorn & Widnes AS, organising the North West Astronomy Festival and setting up Astrofarm in France. He will be missed by his family and friends.

Parker goes public

Data from the Parker Solar Probe's first two solar orbits is now publicly available. "Releasing this data to the public will allow them to contribute to the success of the mission... and also to raise the opportunity for new discoveries to the next level," says Parker's project scientist Nour E Raouafi.

Starliner fails test

The first orbital test of Boeing's Starliner crew module was cut short after an improperly set timer caused it to fire its thrusters at the wrong time. Launched on 20 December, it was meant to dock with the ISS, but was instead forced to land.

NEWS IN BRIEF

Enceladus's cracks

The 'tiger-stripe' cracks found on Saturn's ice moon Enceladus are created by the gravitational push and pull of the planet on the moon, a new study led by the Carnegie Institution for Science has confirmed. The first crack appeared at the southern pole where the ice is thinnest, but didn't immediately freeze over. This allowed the subsurface ocean to erupt out, creating three more parallel cracks.

Cheops launches

The exoplanet studying satellite, Cheops, launched on 18 December 2019. The European Space Agency spacecraft will now watch distant planets to measure their size. This will allow researchers to work out their density and gain a large-scale picture of what kinds of worlds orbit other stars.

Another 60 for Starlink

Space X launched its third batch of 60 satellites into its Starlink megaconstellation on 6 January. Another two launches are planned before the month's end. Starlink will eventually have 12,000 satellites offering global internet, but astronomers are concerned about the impact on night-sky viewing.

NASA/ESA/JPL/SS/CASSINI IMAGING TEAM, DANIELFELA/ISTOCK/GETTY IMAGES, MEADE, NASA/ESA AND D. JEWITT (UCLA)

BULLETIN

Meade files for bankruptcy

The company recently lost a lawsuit brought by a competitor

One of the leading manufacturers of astronomical equipment, California-based Meade Instruments, filed for Chapter 11 bankruptcy on 4 December 2019. The announcement follows on from the company losing a multi-million-dollar lawsuit brought against Meade and its parent company, Chinese firm Ningbo Sunny Electronic Co Ltd, by rival manufacturer Orion Telescopes and Binoculars.

The Orion lawsuit stated that several Chinese firms, including Ningbo, operated a price fixing scheme to drive out firms such as Orion from the market. Orion won the case, receiving up to $50 million in damages.

The terms of the bankruptcy allow Meade to keep trading.

"Please be assured that we will continue to support our products, our customers, and our network of Dealers throughout the process," Meade announced in a recent statement. "We... look forward to continuing the Meade name."

Borisov makes its closest approach

Capturing a comet: the Hubble image of 2I/Borisov

Interstellar comet 2I/Borisov made its closest approach to the Sun on 8 December 2019, passing just twice the Earth-Sun distance away. The Hubble Space Telescope took the chance to observe the comet up close.

"Hubble gives us the best measurement of the size of Borisov's nucleus, which is the really important part of the comet," says David Jewitt from the University of California, Los Angeles, who captured the images. "The radius is smaller than half a kilometre. This is important because knowing the size helps us to determine the total number and mass of such objects in the Solar System, and in the Milky Way."

Borisov is the second interstellar visitor seen in our Solar System, after asteroid 'Oumuamua passed through in 2017. Over the coming years, astronomers expect to discover even more of these long-distance space rocks, thanks to technological improvements to telescopes and an increased number of surveys searching for them.

"Borisov is the first known interstellar comet, and we would like to know how many others there are," says Jewitt.

www.spacetelescope.org

BBC Sky at Night MAGAZINE

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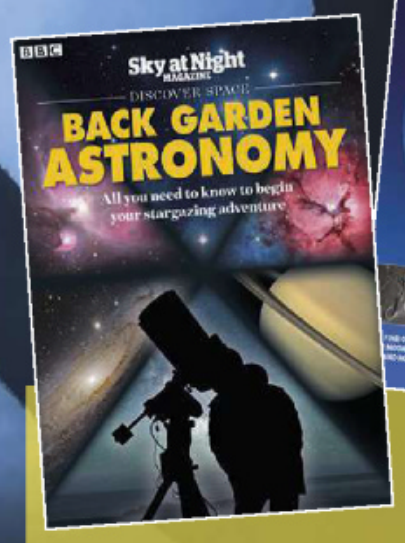

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Our experts examine the hottest new research

CUTTING EDGE

Wild beauty: what type of life could there be on an exoplanet?

Looking for life in exoplanet atmospheres

The equilibrium, or lack of it, in another world's air could point to planets with life

Exoplanet discovery is one of the fastest-moving areas of modern science, with over 4,000 worlds orbiting other suns now confirmed. Detection of an exoplanet is only the first step, though, and astronomers are now beginning to characterise the chemistry of their atmospheres. The ultimate goal would be to find the tell-tale fingerprint of extraterrestrial life in the composition of an exoplanet's gases – an 'atmospheric biosignature'.

In particular, an oxygen-rich atmosphere would be taken as strong evidence of a biosphere, especially if methane was also detected in the air. This is because free oxygen is released by the biological process of photosynthesis but isn't produced by many non-living processes. It's such a reactive gas (combining with methane, for example, to give carbon dioxide) that it ought to be quickly removed from any atmosphere if it's not being replenished. Our oxygen-rich, methane-tinged, atmosphere has been pushed far from the 'chemical equilibrium' you would expect from purely geological processes, a state known as disequilibrium, indicative of Earth's active, global biosphere.

But even though the ability to photosynthesise was developed by life on Earth at least 3 billion years ago, our planet has only had a strongly detectable oxygen biosignature for the last half-billion years or so. It takes time for oxygen to build up in a planet's atmosphere, even if it does support plentiful life.

So how might the atmospheric disequilibrium of Earth have changed over its history, and what other biosignatures might we look for on other worlds? Nicholas Wogan and David Catling from the University of Washington have built a simple computer model of Earth's atmosphere and ocean. The simulation shows how the atmospheric balance shifts with volcanism, sunlight and a simulated microbial population. They used it to study three different phases in our planet's history: the pre-life Earth, when only geological processes influenced the composition of the atmosphere; an Earth inhabited by microbes, able to feed off simple gases like hydrogen and carbon monoxide; and the current age, with widespread photosynthesis controlling the chemistry of the planet.

On an Earth-like planet before widespread life, the atmosphere does show a modest chemical disequilibrium from the mixture of hydrogen and carbon dioxide released from geological sources. So with the spread of primitive life, the atmospheric disequilibrium actually decreases because 'edible' gases like hydrogen are being consumed by microbes. It's not until photosynthesis evolves and adds oxygen to the atmosphere that life conspicuously reveals its presence by shifting the atmospheric disequilibrium.

> ***"Within a few years, astronomers will be able to search for atmospheric biosignatures in nearby transiting exoplanets"***

Spectroscopy of terrestrial exoplanets can not only reveal strong evidence for the presence of a global biosphere, but that certain gases – such as carbon monoxide – could also be considered an 'antibiosignature' indicating the absence of widespread life, because they represent a free lunch that apparently nobody is eating. Within a few years, astronomers will be able to search for atmospheric biosignatures in nearby transiting exoplanets with the James Webb Space Telescope, while scopes planned for the next decade will be capable of picking out the reflected light from Earth-sized exoplanets. We are about to enter a Golden Age for characterising nearby worlds.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *When is chemical disequilibrium in Earth-like planetary atmospheres a biosignature versus an anti-biosignature? Disequilibria from dead to living worlds* by Nicholas Wogan and David Catling. **Read it online at https://arxiv.org/abs/1911.06852**

Finding waves from big black holes

Looking at quasars could help uncover waves from colliding galaxies

Prof Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night*

The detection of gravitational waves by LIGO (the Laser Interferometer Gravitational-Wave Observatory) has transformed astronomy. This sensitive instrument, which uses lasers in long tunnels to detect tiny ripples in space, has opened up a new way of looking at the Universe, and revealed the dramatic effects of merging black holes and neutron stars. Yet there are other ways of searching for gravitational waves which may have effects as profound as that of LIGO, and this month's paper covers the side-effects of one such search.

The collaboration in question, known as NANOGrav, uses radio telescopes at Green Bank in West Virginia and the famous Arecibo dish in Puerto Rico. Rather than looking for gravitational waves directly, they make precise measurements of signals from dozens of millisecond pulsars, each of which spins thousands of times a second. The aim is to look out for the signs of a passing gravitational wave.

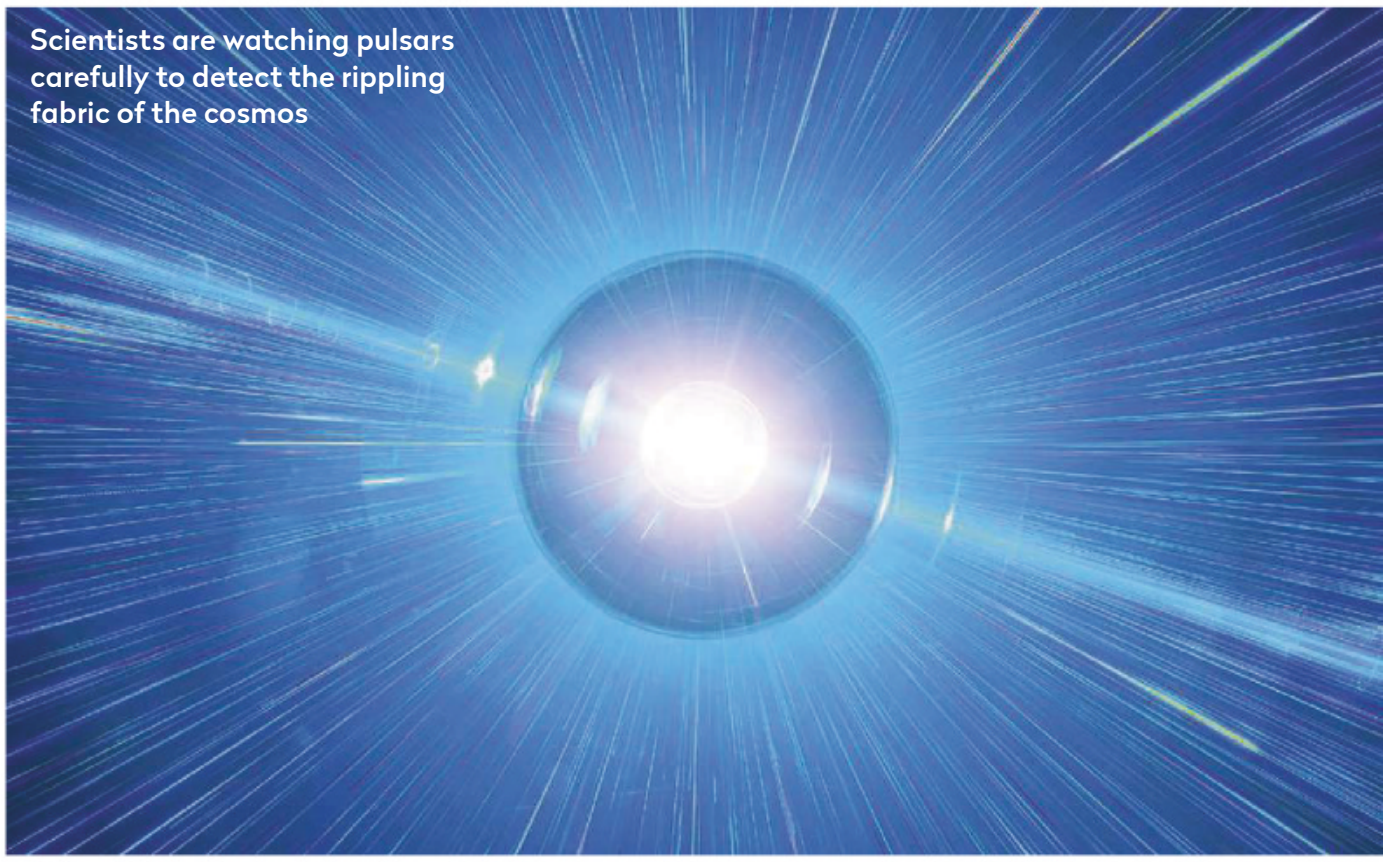
Interferometers such as LIGO, and its European sibling VIRGO, will only ever be sensitive to gravitational waves with short wavelengths, such as those caused by the merging of relatively puny black holes, each perhaps tens of times the mass of the Sun. If the supermassive black holes that lurk at the centres of galaxies, including our Milky Way, merge along with the galaxies that host them, then the waves they produce will pass through Earthbound detectors unsuspected.

Hence NANOGrav and the handful of projects like it scattered around the world. If gravitational waves pass between us here on Earth and the pulsars the astronomers are watching, then the timing of their signals should be subtly altered. Watch enough pulsars carefully, and you might be able to see the fabric of the cosmos rippling in your data.

"The NANOGrav data is sensitive enough that even things the size of the Moon, if close to their parent pulsar, should have shown up"

Not that the pulsars aren't very interesting in themselves. Millisecond pulsars are believed to have sped up to their present rapid rates of spin because of an interaction with a companion, which makes the question of whether there are any planets in such a system particularly interesting. A handful of pulsars are known to have planetary-sized companions, detected by the variation of the pulsar timing caused by the satellite's gravitational pull. As it's assumed no normal planet could have survived the catastrophic supernova explosion which produces a pulsar in the first place, their origin is somewhat mysterious.

So, looking for more pulsar planets in NANOGrav data seems like a great idea, and the team carefully sorted through their trove of data before coming up with, well, absolutely nothing. None of the pulsars in the NANOGrav sample have planets going around them, and that's somewhat surprising. The data is sensitive enough that even things the size of the Moon, if suitably close to their parent pulsar, should have shown up. The absence of planets in this sample tells us that such objects must be pretty rare after all – and that further work finding and monitoring millisecond pulsars is needed for the purposes of both planet detection and gravitational wave hunting.



Scientists are watching pulsars carefully to detect the rippling fabric of the cosmos

Chris Lintott was reading... *The NANOGrav 11-year Data Set: Constraints on Planetary Masses Around 45 Millisecond Pulsars* by EA Behrens et al.
Read it online at: https://arxiv.org/abs/1912.00482

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

▲ **Young observers are advised to look for asterisms such as the Plough in Ursa Major**

KALULU/ISTOCK/GETTY IMAGES, KARRER MICHAEL/ CCDGUIDE.COM, BRITISH SCIENCE ASSOCIATION

January's *Sky at Night* episode revealed how to get started in stargazing, with **Charles Barclay**, director of Marlborough College's Observatory

Anyone who has gazed up at a crystal clear, jet black sky, with stars so bright you think you could touch them, will have felt a sense of awe and wonder. The night sky is part of our global human heritage, largely unchanged (bar our ever-increasing number of planes and satellites) from the sky that our distant ancestors beheld. They wondered at the motions of planets, and the scale and sheer number of stars. The stories created across diverse cultures inspired each new generation and taught navigation, and perhaps laws of conduct and belief systems. Through being based for many years at the same location rising points and times, the intersecting arcs of the celestial sphere, ecliptic and Milky Way planes become obvious.

Running an outreach observatory, I see observers aged from four years to 90 years and it is the 'wow' of first-time observations, perhaps a telescopic view of Saturn, or the Pleiades in binoculars, or a first unaided-eye view of the Milky Way band that inspires. So, when asked by *The Sky at Night* programme, I advised my gathered young observers: dress warmly for if it is clear, it will necessarily be cold. Astronomy demands patience, a quick glance will not suffice (especially given the time needed for one's eyes to become properly dark-adapted). Don't immediately 'think telescopes', they are hard to use and many find aligning one eye with the optical axis and maintaining a steady head challenging; I would always encourage unaided viewing, followed by the use of tripod stabilised binoculars (the larger field of view makes sky-touring easier and there are no inversions of the view to worry about).

Familiarity with the night sky, as seen by eye alone, is most important and one should not dismiss the delight of drawing, rather than going straight to often complex techniques of digital imaging. It is striking to

Charles Barclay is head of physics at Marlborough College and director of its Blackett Observatory

me, that we are in danger of losing this heritage with children, particularly, being too focused on the distractions of modern life and lacking the inspirational experience of truly dark skies. Such dark, clear nights seem to be becoming fewer in our UK climate, not only as our winters become more humid, but also with increasing light pollution and pernicious orange skyglow, masking all but the brightest objects from locations in the proximity of urban areas.

I am always struck by the disappointment in not seeing the dogs, bears, dolphins and other beautifully artistic shapes; few realise that the constellations are simply areas of the sky (like States in the USA). The star patterns are what you make of them and different cultures have such wonderful stories. I encourage my observers to make their own patterns, but recognise and use the objective asterisms, such as the 'Saucepan' (or Plough) in Ursa Major, the 'W' in Cassiopeia or 'Orion's Belt' to find their way around the sky.

Lastly don't go out at night, when the display of myriad stars is perplexing; rather go out at sunset and then as the twilight fades, stars come out in order of brightness and can be learnt.

With good weather, dark skies and patient observing, the patterns and cycles of the night sky are accessible to all.

Looking back: The Sky at Night

7 February 1980

In the February 1980 episode of *The Sky at Night*, Patrick Moore took a look at Saturn. At that time, however, the planet appeared to have lost its famous rings.

The rings disappeared from view because they were edge-on to Earth. Saturn's axis is tilted at 27° to the plane of the planets, meaning its rings are at an angle too. During most of Saturn's 29-year solar orbit, the rings are at least partially tilted towards the Sun, letting us see them from Earth. However, once every 15 years, we see the thin rings from the side, meaning they almost disappear. In between these appearances, the rings appear to grow wider and more circular as they increasingly tip towards the Sun. After around seven years, the rings reach their maximum size, then appear to shrink again.

▲ **The visibility of Saturn's rings changes as they appear to shrink and grow**

Despite the loss of its famous feature in 1980, Patrick was keen to point out that this was a chance to see a unique view of Saturn. The shadow of the rings cut a dark line across Saturn's disc and you could track the rings growing back over the following years.

If you're interested in seeing this different side of Saturn for yourself set a reminder for 23 March 2025, when the rings will next be edge-on.

The Sky at Night returns in April

The *Sky at Night* is taking a break in February and March, and will return in April for more adventures in astronomy and spaceflight. In the meantime, you can visit the official BBC Four website for past episodes and classic clips from the show, including an archive episode in which the late Sir Patrick Moore meets Clyde Tombaugh, the astronomer who discovered Pluto, and a 1970 interview in which Neil Armstrong reveals what it felt like to walk on the lunar surface. The site also includes astrophoto galleries, quizzes and practical guides that will help you navigate the night sky.

Visit bbc.co.uk/programmes/b006mk7h

▲ **Chris Lintott and Maggie Aderin-Pocock will return to our screens in April this year**

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

This month's top prize:
four Philip's books

PHILIP'S The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2020 Stargazing*.

Winner's details will be passed on to Octopus Publishing to fulfil the prize

Trip of a lifetime

Last summer my eight-year-old daughter Ciara, who is obsessed with space, said she would really like to see a rocket launch. That evening, together we wrote to NASA and didn't really expect to receive a reply. A few days later an email landed, incredibly, from Robert Cabana, former Space Shuttle commander, now director of NASA's Kennedy Space Center (KSC). He explained how glad he was that Ciara shared his passion for science and space and how he would be pleased to help grow that passion with personal invitations to the maiden launch of Boeing's CST-100 Starliner spacecraft – the first unmanned test flight. My jaw hit the floor and Ciara screamed with excitement when I told her!

We arrived in Florida eight days before the launch and got news that it had been postponed – twice. The final launch date on 20 December at 06:36 EST was just two days before our return flight to Gatwick. Thankfully it didn't change again. The early launch meant a ridiculously early alarm call of 01:45, to catch a silver NASA bus to the KSC. Everyone else on the bus was a NASA employee or close family – we felt incredibly lucky.

Guests of NASA: Conor and Ciara watch the launch

It wasn't long before the bus stopped at the viewing location, outside the Apollo/Saturn V Center that houses one of the three remaining Saturn V rockets. We had time to explore the exhibits and discovered that a breakfast buffet had been laid out on tables set up alongside the Saturn V rocket.

The bleacher seating outside looked towards the launch site. The Atlas V rocket was several miles away, lit by powerful spotlights. There was a large screen with close-up images of the rocket and a red LED countdown timer. The launch could have been scrubbed at any time, so we kept our fingers crossed until the last second. We counted down with the crowd: 10, 9, 8, 7, 6, 5, 4... fingers still firmly crossed ...3, 2, 1. "We are go for launch!" I wasn't prepared for the brightness of the light – the rocket was no longer discernible, now replaced by a ball of light – as bright as the rising Sun.

Sky high: Boeing's Starliner takes off

It cast a beautiful light pattern over the water below as it moved up, towards the night sky. The crowd were largely silent, and remarkably there was no noise at all from the rocket. The light grew brighter and slowly, surprisingly slowly, the rocket ship and the Starliner spacecraft moved ever higher into the night sky, on its way to the space station. Then the roar of the Atlas V rocket hit us. At first we felt it through the ground, then through the chest, adding to the awe of the spectacle. We watched as the boosters separated high in the sky and the light grew fainter. It was now just a faint speck, blending with the stars in the sky. And then it was gone.

It wasn't long before we were on the flight home. I couldn't resist watching the movie *First Man*, about the life of Neil Armstrong: just a few more hours of 'space' indulgence before arriving back in the UK with Conor and Ciara, excited to share the experience at school. Thank you NASA and Boeing, we are forever grateful!
Matt Crookes, via email

What a stunning adventure to take the family on Matt. Thank you for sharing such a unique experience! ***– Ed.***

Tweets

Cath Adams
@CathAdams1973 • Dec 29, 2019
@skyatnightmag The Moon and Venus over Braunton this evening, what a stunning sight to see #Moon #Venus #Astronomy

Retro view

We asked this month's 'Gallery' winner about the vintage kit he used to get his shot...

The scope I used is a Fullerscopes 8.75-inch f/7.5 Newtonian (pictured above), made sometime in the early 1980s. It's got the 'glamorous' grey plastic tube, but it's fitted with a wonderful David Hinds mirror and a modern motorised focuser which makes it great for lunar imaging. I bought the scope a couple of years ago from a classified ad for £275. They can still be found for sale online, but usually need some TLC to get them working properly, but I feel it's definitely worth it. The mount is an old black SkyWatcher EQ6 from the early 2000s, which is a bit rusty but does the job. I bought it from the family of an elderly astronomer who sadly couldn't use his kit anymore due to ill health. Whenever I get a nice image using his old mount I like to send him a copy so that he can see it's still put to good use. I'm sure he'll be pleased to know his old ▸

ON FACEBOOK

WE ASKED: What are the best targets for astronomy beginners?

Tony Moss The Pleiades, or M45, because it's great to show what you can see with a scope compared to your eye unaided.

Jason Hart The Moon (at around half phase), Saturn, Jupiter and its moons, the Orion Nebula, Albireo; all easy to find, and all look great in a small telescope.

Shona Maloney Orion was the first constellation I learned to spot because of its distinctive Belt. My six-year-old can spot it in the night sky too. Then you can use it to help you find Betelgeuse and Rigel. And once you find Orion there's Sirius and Taurus.

Wendy Keys Definitely something through binoculars to start with: the Andromeda Galaxy and Double Cluster in Perseus; Jupiter with its moons is always a wow.

Chris Shackleton Definitely the Moon from the UK. Because it's always cloudy and you've no chance of seeing anything else!

Alison Edwards M13 is beautiful through a telescope.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I keep my Celestron 9.25 Edge HD in an airtight case in a heated room. Is this a good way to store it?

DUSAN GUBAN

▲ Make sure your telescope is condensation-free before placing it back in its case

Just as your Celestron 9.25 Edge HD telescope needs to be brought down to the ambient temperature for the best observing, it needs to re-acclimatise to the storage conditions to keep it in the best state ready for your next observing session.

It is really important to ensure that the telescope is condensation-free before placing it in its case. On many observing nights, the simple act of bringing the telescope inside your home will be enough to cause condensation to occur. Once the instrument is indoors, place it on a fresh towel on its side and remove any accessories, leaving the visual back uncovered and the dust cap removed.

Wait overnight or until the telescope has reached room temperature with no sign of moisture on any visible surfaces then place it in its case. You may also want to consider adding some extra silica gel sachets to the case, as these will help to soak up any residual moisture in the air.

Steve's top tip

What is a dew shield?

Dew shields are metal or plastic extensions to a telescope's optical tube. They serve two functions; to stop stray light entering the light path from oblique angles and to help keep dew at bay.

At first, a telescope cools down via the movement of air until it's the same temperature as its surroundings. However, after that, the glass elements continue to radiate heat away, which can cause dew to form. A dew shield traps a pocket of air in front of the lens, helping to control the rate of this radiation and prevent dew from building up.

Steve Richards is a keen astro imager and an astronomy equipment expert

CELESTRON, KIRISA99/ISTOCK/GETTY IMAGES

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▸ rusty mount helped to create an image of the month!
Craig Towell, Bristol
You can see Craig's winning photo on page 80. **– *Ed.***

Grand day out

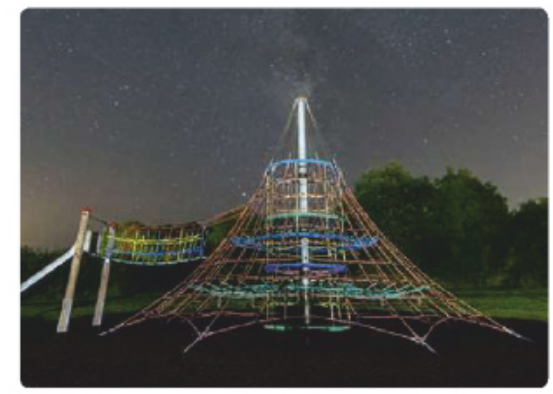
On 9 November 2019 members of the Loughton Astronomical Society visited the Mullard Radio Astronomy Observatory, near Barton in Cambridgeshire, where Jocelyn Bell Burnell discovered pulsars in 1967.
Jack Martin, Huggins Spectroscopic Observatory

Divine inspiration

I liked Brother Guy Consolmagno's '12 sights of Christmas' (December 2019) – in particular the inset in each of the images showing what you would actually see using the equipment and magnification suggested.
Doug Wells, Oxford

Tweets

Craig Chew-Moulding
@tmosphaera • Jan 1
Universal Playground - My first post of 2020. The #MilkyWay rising from a playground at #Charmouth @SkyAtNightMag



Correction

The feature 'Two centuries of discovery: The Royal Astronomical Society turns 200' (January 2020 issue) wrongly stated that Prof Dame Jocelyn Bell Burnell received a 1974 Nobel Prize in Physics for her part in the discovery of pulsars. Despite being the first to observe pulsars in 1967 as a graduate student, she was not recognised in the Nobel Prize award, which cited her thesis supervisor Antony Hewish and astronomer Sir Martin Ryle.

SOCIETY IN FOCUS

The **Coventry & Warwickshire Astronomical Society (CAWAS)** celebrated its 80th anniversary in November 2019. The meeting to mark the occasion opened with some historical comments from chairman John Davis, and was followed by our regular 'Skynotes', a review of forthcoming astronomical events to keep an eye on over the month ahead, given by Society member Mark Edwards. We celebrated our anniversary with three birthday cakes and drinks, followed by an excellent lecture by Dr Julian Onions on galaxies. It was a great evening, enjoyed by all who attended.

CAWAS was originally formed through an association with Coventry Technical College, and a merger in 1974 with Warwickshire AS resulted in the Society we enjoy today. We meet on the second Friday of each month at Earlsdon Methodist Church Hall in Coventry at 7.15pm. Meetings include our Skynotes, a discussion of members' observations and a visiting speaker.

Help is on hand for beginners and encouragement for young astronomers is important. In recent years two younger members, Cameron Watson and Tom Killestein, have won the Patrick Moore Achievement Award, presented annually by the British Astronomical Association.

Observing opportunities are also available at sites around Coventry, including at the local Rugby Cricket Ground. We look forward to meeting any new members.
John Fell, committee member, CAWAS
▸ www.covastro.org.uk

Our pick of the best events from around the UK

WHAT'S ON

NI Science Festival

Various venues, Northern Ireland, 13–23 February

A hefty dose of space stuff is promised in this year's festival, including the Science of *Star Wars* Tour, lectures, crafts, films, workshops, exhibitions and planetarium shows.

www.nisciencefestival.com

Hebridean dark skies festival

Lewis, Outer Hebrides, 7–22 February

Under some of the darkest skies in the UK, this new annual event in Stornaway and across Lewis is packed with astronomy talks, films, theatre shows, music and stargazing. Book tickets by calling 01851 708480 or at **lanntair.com/events/category/dark-skies-festival**

South Downs Dark Skies Festival

Hampshire, East and West Sussex, 7–23 February

Two weeks of free family fun, star parties and talks, including planetarium shows, a virtual reality experience, giant dark night skies colouring wall and outdoor stargazing if weather permits.

bit.ly/southdownsdarkskies

Night Sky Show

Lincoln Drill Hall, Lincoln, 8 February, 8pm

Promising to give boring the boot, this is an evening of space chat and comedy with Adrian West (well known as VirtualAstro on Twitter) for anyone with even a passing interest in stars, constellations, planets and deeper space. Tickets from £12.

bit.ly/nightskyshow

NI SCIENCE FESTIVAL, STEVE BELL NYMNPA X 3, POLLY A BALDWIN

PICK OF THE MONTH

▲ Due north: enjoy stargazing in locations around the North York Moors and Yorkshire Dales

Dark Skies Festival Yorkshire

North York Moors and Yorkshire Dales, 14 February–1 March

Returning for its fifth year, 2020's Dark Skies Festival Yorkshire will again showcase the beauty of one of the UK's least light-polluted regions.

Good clear conditions in the North York Moors and Yorkshire Dales – home to three Dark Sky Discovery Sites, at Sutton Bank and Danby National Park Centres, and Dalby Forest – can reveal over 2,000 stars in one glance. But if that's not draw enough, there will be over 100 events taking place in the two national parks over the festival fortnight.

From 'stay and gaze' experiences and dark-sky yoga and mindfulness events, to gravel biking challenges and night-time zip wiring, there will be plenty of ways for visitors to get to know the night sky. Other highlights include stargazing safaris, ghost walks, astrophotography workshops and night navigation hikes.

Also, look out for a talk from *The Sky at Night* co-presenter Chris Lintott. While some events are free, charges for others start from £10. Book in advance. **bit.ly/darkskiesfestival**

From Birr to Hubble

Carding Mill, Shrops, 15 February, 7.30pm

This talk explores the Leviathan of Parsonstown, once the largest scope in the world, and how it unlocked the path to the Hubble Space Telescope. Bring your scope and binoculars. Tickets £11.

bit.ly/nationaltrustbirrtohubble

Delamont Country Park stargazing

Killyleagh, County Down, 21 February, 7pm

Everyone is welcome at the Northern Ireland dark-sky location Delamont Country Park Campsite to join the Irish AA for one of their regular observing sessions.

irishastro.org.uk/observing

FOR EVERY ASTROPHOTOGRAPHER

Image of M51, courtesy of Zoltan Nagy

THERE'S AN ATIK

Whether you choose to explore stunning wide field vistas or focus on Arp's peculiar galaxies; no matter what your level of expertise, we'll have the camera for you.

If you're looking for dedicated video astronomy then the Infinity camera will deliver deep sky to screen in seconds. The high speeds and high quality of our Horizon II CMOS camera will lend itself to both planetary and deep sky imaging. If it's a highly sensitive, affordable cooled CCD camera you have in mind, our 4-series will have a camera for you. Or maybe you would prefer the fully integrated solution of the Atik One, or our exceptional large format cameras that will deliver stunning full frame results.

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FIELD OF VIEW

How remote astronomy changed my life

Despite a surprising opposition from some quarters, **Pete Williamson** found his love of stargazing was revitalised by gaining access to the world's observatories

Pete Williamson is an amateur astronomer and teacher of remote astronomy. He is an imaging consultant for the Faulkes Telescope Project

Amateur astronomy has had me hooked since 1967. When I moved to rural Shropshire in 1989 I was living an amateur astronomer's dream – a totally dark location, and great easterly, southerly and westerly horizons with no obstructions.

Over the years the dream has faded. First, security lights began to appear on properties nearby, then structures were built that obstructed our view of the night sky, until even solar observing from the garden became impossible. Then my declining ability to move equipment from the house into the garden, caused by a back injury, became more of a factor and hindered my love of visual and photographic astronomy.

But my life changed for the better after a chance conversation with a colleague at an astronomy event introduced me to the world of remote astronomy. This was just what I needed: companies whose telescopes could be controlled over the internet, with observatories in both the Northern and Southern Hemispheres. No more would I have to suffer the stiffness of movement the day after, or the cold winter nights, or the expense of equipment I could not afford.

I now had at my fingertips remote observatories with research-grade kit fitted with high-end CCD cameras; telescopes that are automatically focused and guided by default; and a high-quality data pipeline that had dark, flat and calibration frames applied during observing runs.

I realised quickly that the extra beauty of doing astronomy with remote telescopes was that you could image objects unseen in the UK night sky. Constellations such as Carina, the Keel, only reveal their treasures to Southern Hemisphere eyes, and never rise above the horizon at my location in Shropshire. There's an added bonus too, in that you can schedule your imaging runs to take place when you're unable to do the observation live.

I took to this way of working and had many images published, plus the opportunity to carry out remote imaging as part of my job. I wrote a lecture about it and delivered it across the UK and Ireland. But I was unprepared for the response. I found a fair bit of opposition: I was accused of undermining astronomy, of not doing it properly, even of promoting its demise.

This response has always struck me as strange. After all, the astronomy you do, be it reading books, visual observing, local-based imaging, scientific research or remote telescope usage is *your* astronomy – *your* choice. And there's another point to consider here too: remote astronomy is how the professionals have operated for years. By saying that amateur astronomers who image remotely aren't doing real astronomy, does that also mean professional astronomers working in similar ways aren't taking their branch of science seriously either?

It's heartening to see that views about this branch of astronomy are changing, and as a result the true value of remote astronomy is being realised, whether that's through educational services like the Faulkes Telescope or the Liverpool Telescope, or paid-for services such as iTelescope or Slooh.

SON OF ALAN/FOLIO ART

BBC

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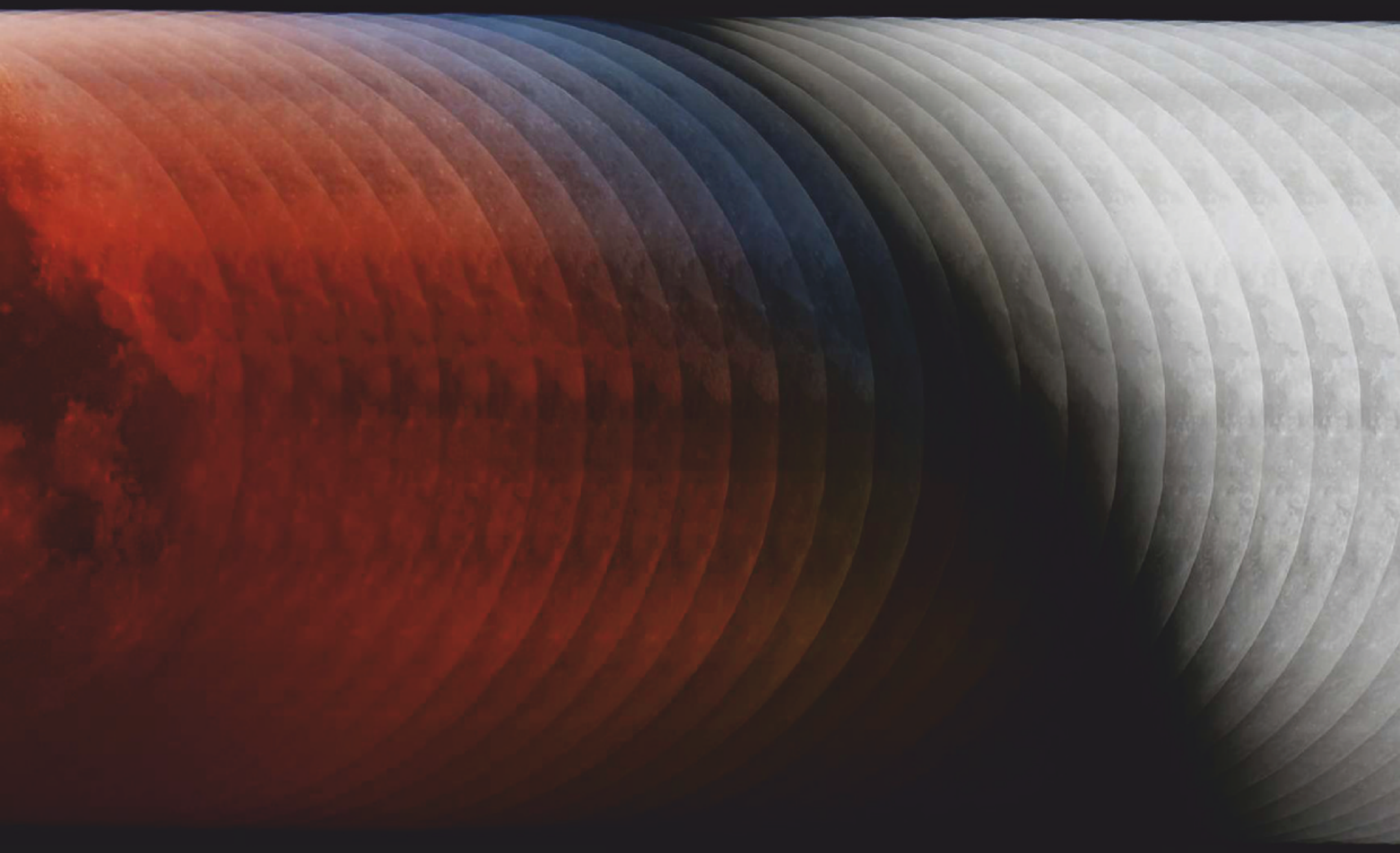
BBC Sky at Night MAGAZINE

Insight Investment Astronomy Photographer of the Year

The competition to crown this year's best astrophotographer is now open



Into the Shadow: László Francsics won the 2019 competition with this stunning lunar eclipse montage

The time has come to gather your best images, perfect your processing and select your favourite astrophotographs to enter into the Insight Investment Astronomy Photographer of the Year 2020, which opens for entries this month. Could you be crowned this year's winner and take home the £10,000 grand prize?

Whatever your skill level or preferred target, there's a category to suit you. If your skills lie in processing rather than capturing images, then the new Annie Maunder Prize for Image Innovation gives you the chance to show off your skills using data from the world's best telescopes. The competition is not just a test of technical skill, though. To stand a chance of winning, astrophotographers also need to show off an artistic eye and find a new way to make their target stand out.

"A good astrophotograph is precise: it has an accurate composition, colour balance and contrast," says László Francsics, winner of 2019's competition. "But for an award-winning image, this is not enough. These images have the unique power to show that new possibilities and perspectives do exist. Astrophotographers have to be courageous when choosing their target, daring when creating the concept of the image, and persistent when out in the field. They have to push their limits as far as they can."

Dates for the diary

Competition opens: 13 January 2020
Closing date: 6 March 2020

How to enter and rules:
To put yourself in the running to become the next Insight Investment Astronomy Photographer of the Year, and to read the full terms and conditions, visit the competition website: **www.rmg.co.uk/astrocomp**

CATEGORIES

There are many categories to choose from and you can submit multiple times

Aurorae

Its ever-shifting nature means no two images of the aurora are the same. Whether Northern or Southern, if your image features a display of the Lights then it's eligible for this category.

People and Space

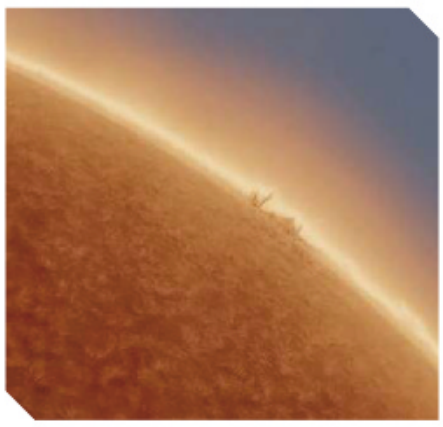
This category celebrates humanity's connection to the cosmos. If your image shows the presence or influence of humans next to the night sky, it can be entered here.

Skyscapes

Always a popular category, Skyscapes is for any image featuring a celestial backdrop against an earthly foreground – whether it's a city skyline, a remote hilltop or a rolling sea.

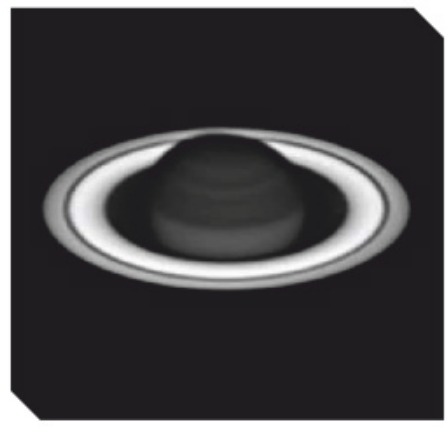
Our Moon

The Moon's ever-changing face means lunar photography offers many chances to get creative. Whether an eclipse or a close-up of a crater, lunar images belong here.



Our Sun

Our nearest star provides astrophotographers with a unique challenge, but can also provide spectacular imaging opportunities for this category.



Planets, Comets and Asteroids

This category is for those images which manage to capture any of the host of interesting objects wandering through our Solar System.

Stars and Nebulae

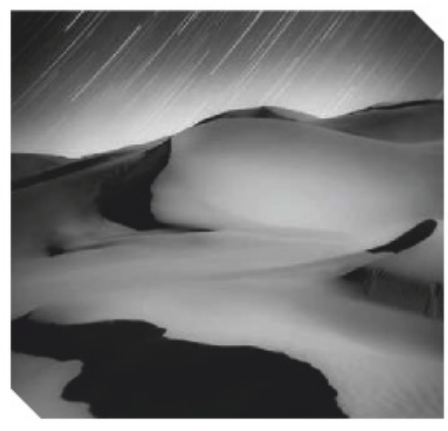
Our Galaxy is home to many beautiful sights: nebulae, star clusters and constellations to name a few. Your best images of them belong here.

Galaxies

Beyond the confines of the Milky Way are billions of other galaxies, giving thousands of options to consider when picking a target to enter.

Young Astronomy Photographer of the Year

Open to entrants aged 15 and under on the closing date, this special competition helps to foster the astrophotographers of tomorrow.



Special Prize: Patrick Moore Prize for Best Newcomer

If you only turned your camera towards the night sky for the first time after January 2019, then you're eligible for this special prize.

Special Prize: Annie Maunder Prize for Image Innovation

More and more pro observatories on Earth and in space are making their data open source. This new prize asks astronomers to take these images and add their own creative spin. Whether it's creating a mosaic from Curiosity pictures or processing an undiscovered gem in Hubble's catalogue, if you've ever wanted to craft a beautiful image using data from top scopes, here is your chance.

LÁSZLÓ FRANCSICS, JAMES STONE, RUSLAN MERZLYAKOV, RAFAEL RUIZ, JASON GUENZEL, MARTIN LEWIS, LLUÍS ROMERO VENTURA, RAUL VILLAVERDE FRAILE, THEA HUTCHINSON, SHUCHANG DONG, STEVE MARSH/PROCESSED FROM NASA/JPL-CALTECH DATA

A first night under THE STARS

The dark early evenings at this time of year are the perfect time for you and your family to get to know the night sky. Follow **Stuart Atkinson's** 10 easy steps to get you stargazing

BBC iPlayer

For more about starting out to discover the night sky, watch the latest *Sky at Night* episode *'A beginner's guide'* on iPlayer now

Things are looking up: there's so much you can discover with naked-eye viewing

Bright lights can be a thorn in the side for astronomers. For a better experience, choose a sight away from them

This time of year memories of Christmas and the New Year are beginning to fade, and with the Sun still setting late in the afternoon many people will be looking to the sky and wishing they knew more about what's 'up there' – especially if there was a telescope under the Christmas tree.

If this is you and you still haven't a clue how to use that telescope, don't be disheartened. After all, the night sky won't be completely alien. You'll have seen the Moon countless times before, perhaps while loading up the car at the supermarket.

You want to dress like one of the rosy-cheeked children playing in the winter snow from a vintage Ladybird book

► **In all weathers: wrapping up warm is essential for astronomy**

No doubt you'll have spotted a bright planet or two shining in the twilight when you've been walking home from the pub or gym, or watched the International Space Station (ISS) arcing across the sky before dawn as you headed to work. But you'll have an infuriating itch you can't scratch: knowing there are probably lots more amazing and fascinating things to see up there – if only you knew where to start learning about them...

If that sounds familiar, then this feature is for you.

Granted, bad weather will be a problem, but there's nothing anyone can easily do about that. Something which is easier to deal with is the misconception that, if you want to get into stargazing and want to see anything in the night sky you have to spend a lot of money on high-tech equipment such as Go-To telescopes and CCD cameras. What if you just want to start at the very ground level of the hobby and don't want to buy anything? What can you see up there just by stepping outside and looking up with your eyes? Over the following pages, we take you on a first night's tour of the night sky in 10 easy steps...

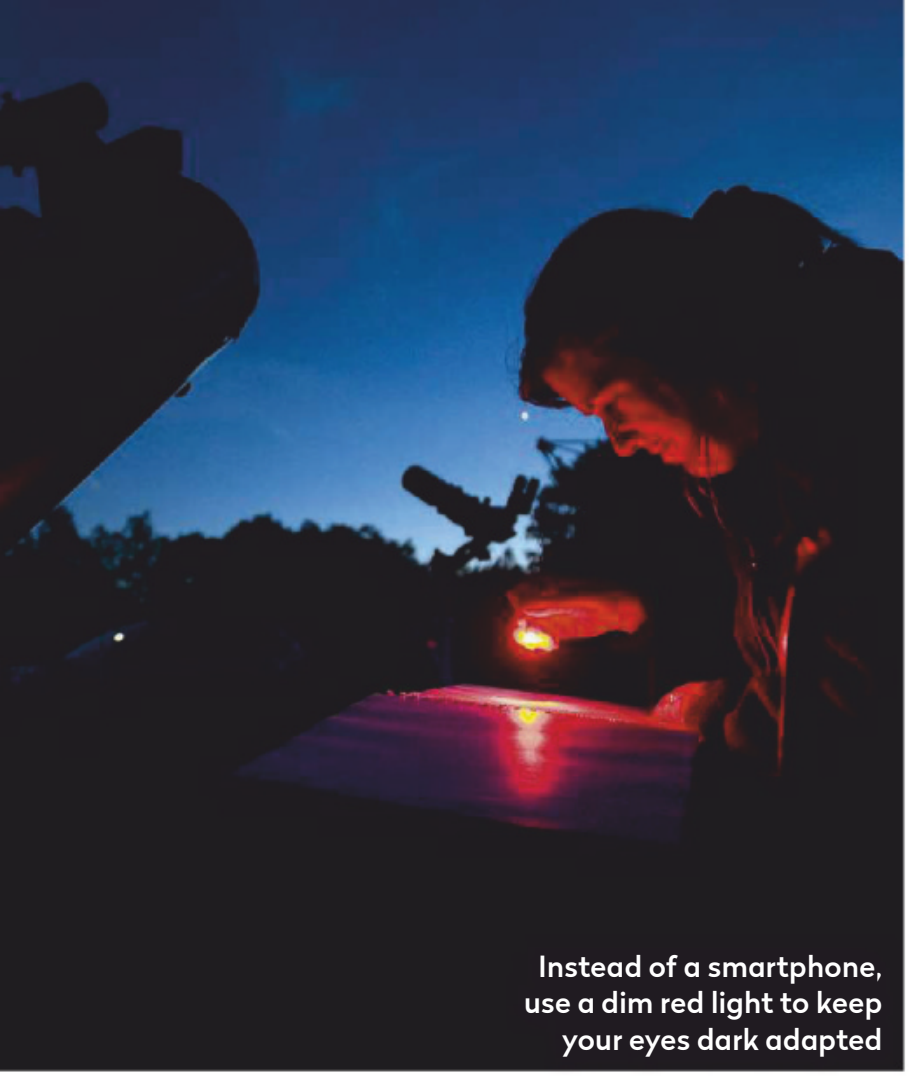
1. Be prepared

Before you even look at the sky, take a look at yourself in the mirror. Are you dressed properly? You're going to be outside for at least an hour, hopefully longer, so dress appropriately for the cold, with a warm jacket, thick socks, gloves, scarf and a hat. Basically, you want to look like one of the rosy-cheeked children playing happily in the winter snow from a vintage Ladybird book.

2. Choose your observing site

If you're lucky you'll be able to stargaze from your back garden, but it might not be the ideal place. Your garden could be surrounded by other houses, tall buildings and trees, which all reduce the amount of sky you can see. And light pollution coming from nearby streetlights, pubs, shops and factories, and neighbours' security lights, can take even more of your view away. If this is the case, get away from all that. Head out of town to a dark spot in the ►

WILL GATER, ANATOLIY GLEB/ISTOCK/GETTY IMAGES, STUART ATKINSON, WWW.SECRETSTUDIO.NET



Instead of a smartphone, use a dim red light to keep your eyes dark adapted

Most stars are an icy white colour, but after dark-adapting your eyes will make out that some are more of a bluish colour while others are yellow, orange or even red

▸ countryside, or even just walk around the corner to your local park or school playing field. It'll make a big difference to what you can see.

3. Dark adaptation

Once you've found your observing site you'll need to give your eyes time to get used to the darkness. Astronomers call this process 'dark adaptation' and it takes about half an hour. After your eyes have relaxed, opened up their pupils to take account of the reduced light levels and released special chemicals to enhance their sensitivity, you won't believe how many more stars you can see than when you first arrived. Don't browse on your phone while you wait; its bright screen will ruin your night vision.

4. First look

As you become dark-adapted you'll see a few bright stars dotted across the sky, and one very bright one shining in the western twilight. Surprise: that's not actually a star, it's the planet Venus. You can see all the planets out to and including Saturn with your eyes alone, although they're not all visible at the same time. To the eye Venus is by far the brightest and fairest planet, shining like a beacon in the east when it's the 'Morning Star' before sunrise, or in the west when it's the 'Evening Star' after sunset. All through this month Venus will be a striking object in the west after dark, and between the 26th and 28th it'll be joined in the sky by the crescent Moon, making a lovely sight.

5. It's full of stars

Eyes successfully dark-adapted, you'll notice that the sky is full of stars, many more than you ever see with just a glance from a light-polluted site. You'll realise that some stars are brighter than others, but before we look at why that is, a question: what are stars?

Well, the Sun is a star. It's essentially just the closest star to Earth, a mere 146 million km away. That's very close in astronomical terms, but still so far away that the Sun's light – travelling at 1,080,000,000 (1.08 billion) km/h – takes over eight minutes to reach us. When the Sun sets we then see stars much further away, so far away that their light takes years, not minutes, to reach us.

Every star is a distant Sun and they are all different distances away from us. So a bright star is just closer to us than a faint star, right? Well it's not quite that simple. Like light bulbs, some stars are brighter and more powerful than others. So just because a star is faint in the sky it doesn't mean it's a low power one; it might be a very luminous star a great distance from us. Likewise, a bright star in the sky might be a weak star that's close.

You'll see differences in the stars' colours too. Most stars are an icy white colour, but after dark adapting your eyes you will make out that some are more of a bluish colour while others are yellow, orange or even red. This is because stars have different temperatures. Blue stars are much hotter than orange stars, which makes sense if you consider the difference between a warm yellow candle flame and the fierce blue flame of a blow torch.

Stars aren't just different brightnesses and colours. Some are smaller than our Sun, others are much larger, but those differences aren't apparent to our naked eyes.

From the 26–28 February Venus will be close to the crescent Moon, making a lovely evening sight

ZUMA PRESS/INC/ALAMY STOCK PHOTO, STUART ATKINSON, YURIY KULIK/ISTOCK/GETTY IMAGES

Planetarium apps

Five planetarium apps that will help you around the night sky. Just turn your screen brightness right down, or make it red to keep your night vision!

Stellarium Mobile Free

It's missing the whistles and bells found on other apps, but Stellarium's simulation of the night sky is beautifully realistic and gives a true impression of what the sky looks like.

SkySafari

The free version of this feature-packed planetarium app gives you all the information you need to plan your observing sessions, and enjoy eclipses and other astronomical events.

Star Tracker

A basic app that will help you identify stars, constellations and planets as you sweep your phone or tablet around the night sky. Beautiful graphics, but slightly annoying music.

Mobile Observatory Free

A powerful app with so many features it's more like a full PC software package. Its renders of the night sky are realistic and useful for showing astronomical events in advance.

Heavens-Above

A very useful app that doesn't simulate the stars or constellations like the others, but alerts you when the International Space Station and other satellites will be visible.

▲ **The Plough is one of the most recognisable sights in the night's sky**

6. Patterns in the sky

Once you're dark-adapted it won't take you long to notice that the stars can be joined up to form patterns. You might recognise one straight away. Look to the north and you'll see the giant saucepan-shaped Plough balanced on the end of its handle. But the Plough isn't a constellation – it's an asterism, a small pattern of stars immediately obvious to the naked eye. The Plough forms part of the constellation of Ursa Major, the Great Bear. The Plough's handle represents the bear's tail, and fainter stars around it form the bear's legs and head. Turn your back on the Plough to face south and you'll see another constellation – Orion, the Hunter. Orion famously has a belt of three sapphire blue stars pulled tightly around his waist, making him impossible to miss. There are 88 constellations in the sky, but very few look like the person, animal or object they represent. You need a lot of imagination to recognise most of them!

7. Planet-spotting

How can you tell which bright stars are actually planets? There's an easy way to tell them apart: stars twinkle, planets don't. This is because while stars are points of light, planets are tiny discs, so stars are affected more by the movement of the air. If you see a bright 'star' that isn't twinkling, it's almost certainly a planet. But which one? We'll tell you how to identify them later in this feature... ▸

Youngsters can immediately locate targets without too much trouble

Getting kids involved

With darkness descending early, now is a great time to get the family involved in some stargazing

One of the best things about stargazing is that it isn't just a hobby for adults, children can enjoy it too. There are several fascinating things in the February sky which they can find themselves without too much trouble, or can be guided to quickly with a subtle hint.

First of all, as soon as you get to your observing site, ask your youngsters if they can find the 'Evening Star'. Give them the clue that it's the brightest object in the sky after the Sun and Moon, and they should quickly locate Venus blazing in the west.

Next, once their eyes have dark-adapted, ask them to look for Orion's Belt – with the advice that it looks like three blue-white stars close together in a line. It won't take them long to find it pulled tightly around the Hunter's waist as he stands confidently above the southern horizon, over to the right of Venus.

With Orion's Belt in the bag, ask them next to look for the Plough. This is such an obvious and well-known asterism that they might go right to it, but if they need a little help tell them they're looking for a huge spoon made of stars and in a matter of moments they'll locate the Plough, balanced on the tip of its handle, almost directly opposite Orion. If they can't find it, ask them to find a big question mark of stars, and they should go right to it.

Finally, ask your young stargazers if they can find Polaris, the Pole Star. Don't be surprised if – sharing the common misconception many adults have that Polaris is the brightest star in the whole sky – they point out Sirius, the brightest star in the sky, or even Venus. Show them how to find Polaris using the pointers in the Plough.

▸ 8. What was that?

After a while you will almost certainly see a star dash across the sky – a meteor, or shooting star! These are tiny grains of space dust burning up in the atmosphere. Very bright ones, called fireballs, can drop meteorites on the ground. Satellites look like faint stars and move much more slowly, taking a minute or more to cross the heavens. The largest satellite, the International Space Station (ISS), can shine as brightly as Venus as it sails across the sky.

9. They've moved!

If you stay at your observing site long enough you'll notice that the stars which were low in the east when you arrived have climbed higher in the sky, and those which were low in the west are lower or might even have vanished from view altogether. Why? It's because as Earth rotates the stars appear to sweep across the sky. Only one star stays still: Polaris, the Pole Star, which is aligned with Earth's axis and can be found using the 'Pointer' stars in the Plough.

Return to your observing site in August or September and you'll see the whole sky has changed. This is because the constellations we see change during the year, as Earth orbits the Sun. Each season has its own constellations, which is why it takes a year to properly learn the sky and not just one night.

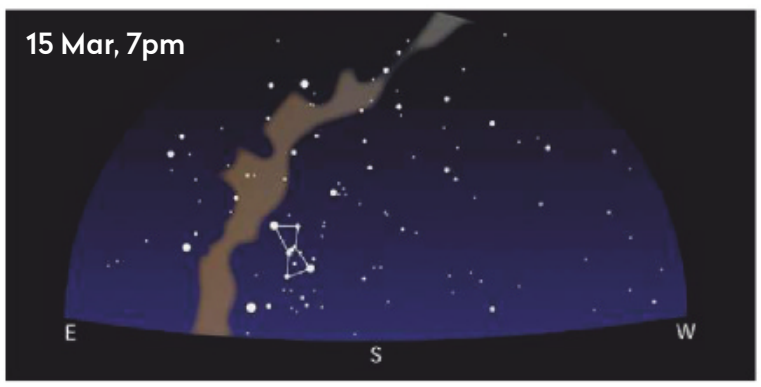
Standing proud: Orion, the Hunter is a prominent constellation in the winter night's sky

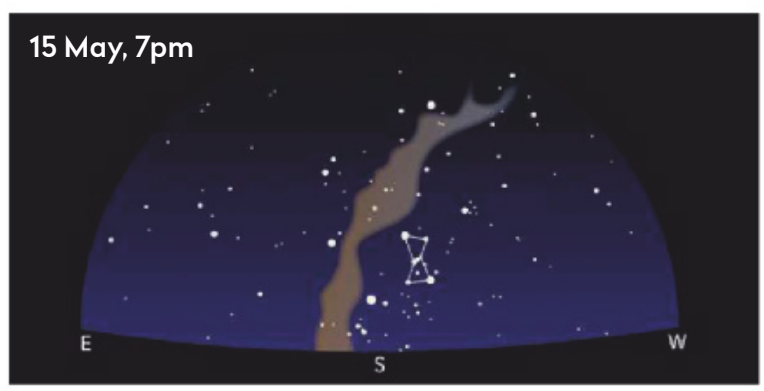
The stars revolve around Polaris, the bright point in the centre of the star trails in this image

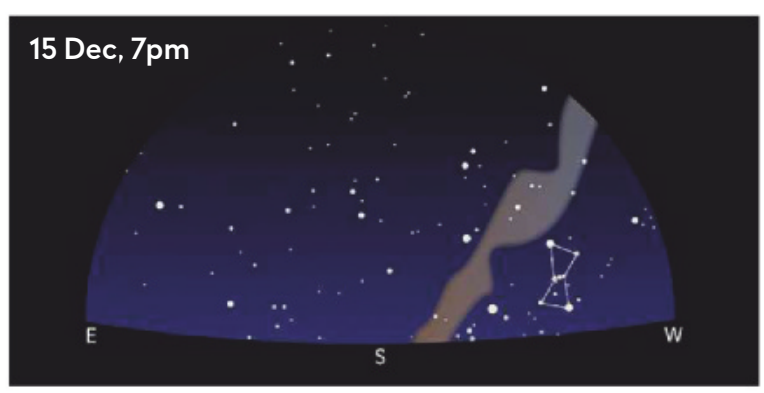
Stuart Atkinson is an amateur astronomer and the author of nine books

10. Don't wait to get started

You don't need to spend a fortune – or any amount of money – to start to enjoy stargazing as a hobby. All you have to do is find somewhere away from bright lights, with a good view of the sky, and on your very first night you'll see and learn a lot. Why wait to get started, there's so much to see every night.



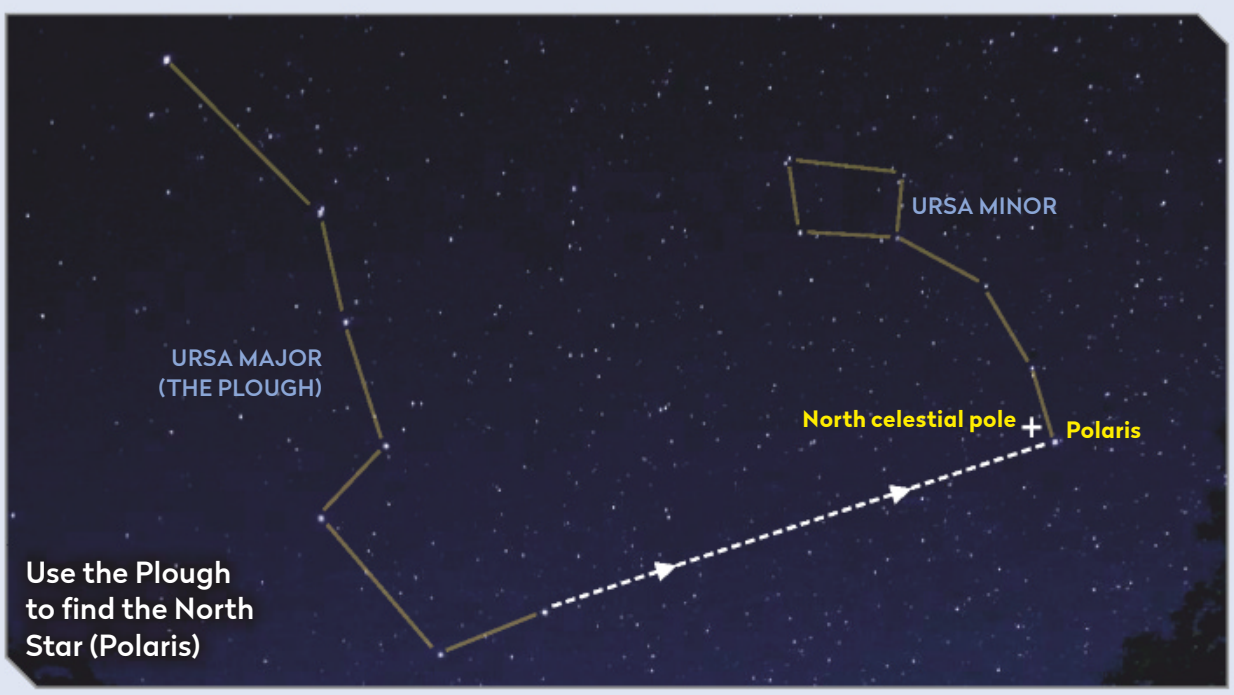




► **Earth's movement through space causes the constellations to move over the course of the year**

Set out on a star hike

Find your way to objects without an app by 'star-hopping'. Here are four popular hikes to set out on in February's sky



Use the Plough to find the North Star (Polaris)

On the trail of the Pole Star

Beginners are often shocked to learn that the Pole Star (Polaris) is not the brightest star in the sky and struggle to find it.

Thankfully you can star-hop to it from the Plough (Ursa Major) using the two 'pointer stars' on the far side of its bowl, which point straight towards Polaris.

Let's get Sirius

Whatever the time of night, like a mossy signpost on the corner of a country lane, Orion's Belt will always point you towards Sirius. Think of it as an arrow pointing both left and right. Follow it downwards to the left and you'll go straight to Sirius, twinkling low in the sky just above the horizon.

Finding the Hyades and the Pleiades star clusters

If you extend Orion's Belt in the opposite direction to Sirius you'll come to not one but two beautiful star clusters in the constellation of Taurus. First, the V-shaped Hyades cluster, which represents the Bull's fearsome horns, and further beyond that the Pleiades or 'Seven Sisters' cluster of stars.

Spotting the bright star Arcturus

Having used two of the stars of the Plough (Ursa Major) to find Polaris you can use three others to find Arcturus, the fourth brightest star in the sky in the constellation of Boötes. Just use the Plough's curved handle as a guide by "following the arc to Arcturus".

BIRTH OF TRULY BEAUTIFUL ASTROPHOTOGRAPHY

Photo: Phillipp Keltenich, sternenhimmel-fotografieren.de **Taken with:** Pro APO 71/450 Quadruplet

The beauty of excellent astrophotography is admired by everyone. Would you like to become one of the astrophotographers who create such images? You too can make this dream a reality with an Omegon premium apochromat, featuring an outstanding ED doublet, triplet or quadruplet lens and employing FPL-53 glass. With super-flat image fields and pin-sharp stars right up to the edge of the image. Of course the precision mechanics of the CNC-machined OTA are also impressive: all focusers are precision rack-and-pinion focusers with a high load capacity and 360° rotation for optimum image capture. This is the start of better astrophotography.

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- Look forward to observations and images that will remain in your memory

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Weight 1.7 kg | 3.7 lbs	**60852**	60mm f/5.5	doublet ED	2" focuser with 1:10 reduction	**549**
Pro APO 72/400 Doublet OTA					
Weight 2.0 kg | 4.4 lbs	**60853**	72mm f/5.6	doublet ED	2" focuser with 1:10 reduction	**539**
Pro APO 71/450 Quadruplet OTA					
Weight 2.5 kg | 5.5 lbs	**60855**	71mm f/6.3	quadruplet ED	2.5" focuser with 1:10 reduction	**629**
Pro APO 80/500 Triplet OTA					
Weight 3.7 kg | 8.2 lbs	**60856**	80mm f/6.3	triplet ED	2.5" focuser with 1:10 reduction	**989**
Pro APO 80/500 Triplet Carbon OTA					
Weight 3.4 kg | 7.5 lbs	**60857**	80mm f/6.3	triplet ED	2.5" focuser with 1:10 reduction	**1019**
Pro APO 90/600 Triplet OTA					
Weight 3.8 kg | 8.4 lbs	**60858**	90mm f/6.7	triplet ED	2.5" focuser with 1:10 reduction	**1019**
Pro APO 107/700 Triplet OTA					
Weight 6.0 kg | 13.3 lbs	**60859**	107mm f/6.5	triplet ED	3" focuser with 1:10 reduction	**1719**

The shape of the AURORA

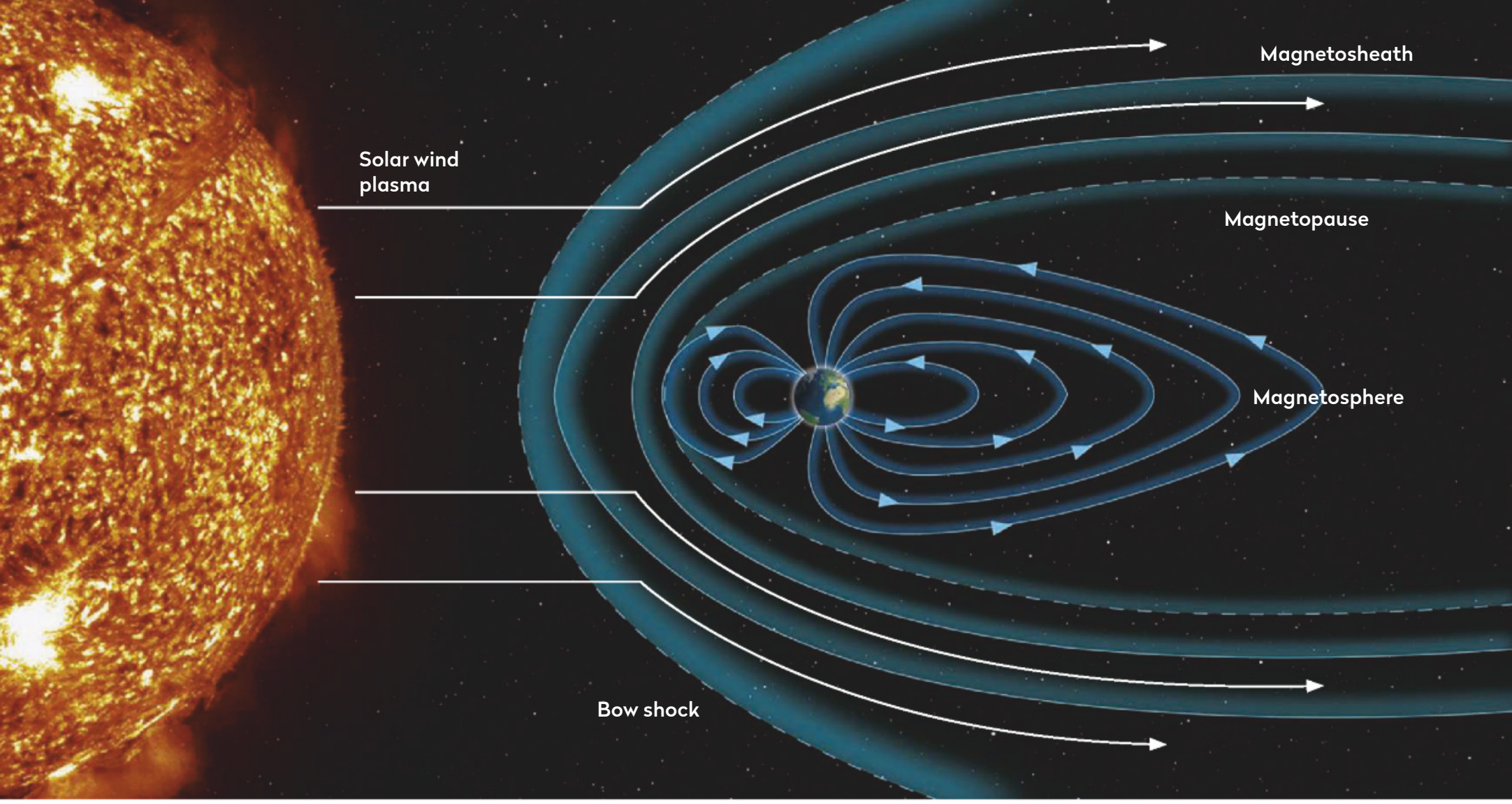
The shifting face of Earth's cosmic light show is miraculous to see. **Melanie Windridge** explains the science behind the aurora

Green sky at night: the aurora is caused by charged particles interacting with our atmosphere

STOCKTREK IMAGES, INC./ALAMY STOCK PHOTO

Standing by the railing of the cruise ship, I looked out at a band of dull green aurora slowly twisting over the low mountains of the Norwegian fjord. I had never experienced the aurora on a ship before and I enjoyed seeing the landscape slowly change as well as the aurora. But even if I had seen them from a cruise before, it wouldn't have taken away the excitement. The aurora is always new. The anticipation is always there. The aurora makes you wait, wishing for clouds to clear or for solar particles that were released days ago to suddenly come quicker or stronger. The aurora fosters hope and gratitude. Because you never know what you will get, and every aurora is different.

The aurora is a polar light show caused by the interaction of charged particles flowing from the Sun — known as the solar wind — with Earth's magnetic field. This sets up a cycle of changing fields and currents that ultimately accelerates electrons into Earth's upper atmosphere (the ionosphere) on the night side of the planet. These electrons collide with atoms in the atmosphere, mostly oxygen and nitrogen, transferring some of their energy to the atoms, which then release it as light. This atomic process, happening to billions of atoms stretching up hundreds of kilometres into the atmosphere, creates the soft, moving light of the aurora. ▸



▲ **Magnetic meeting: Earth's magnetic environment meets the charged solar wind to drive the aurora**

ILLUSTRATIONS BY PAUL WOOTTON, SOHO/NASA & ESA, MANTAPHOTO/ISTOCK/GETTY IMAGES, MLENNY/ISTOCK/GETTY IMAGES

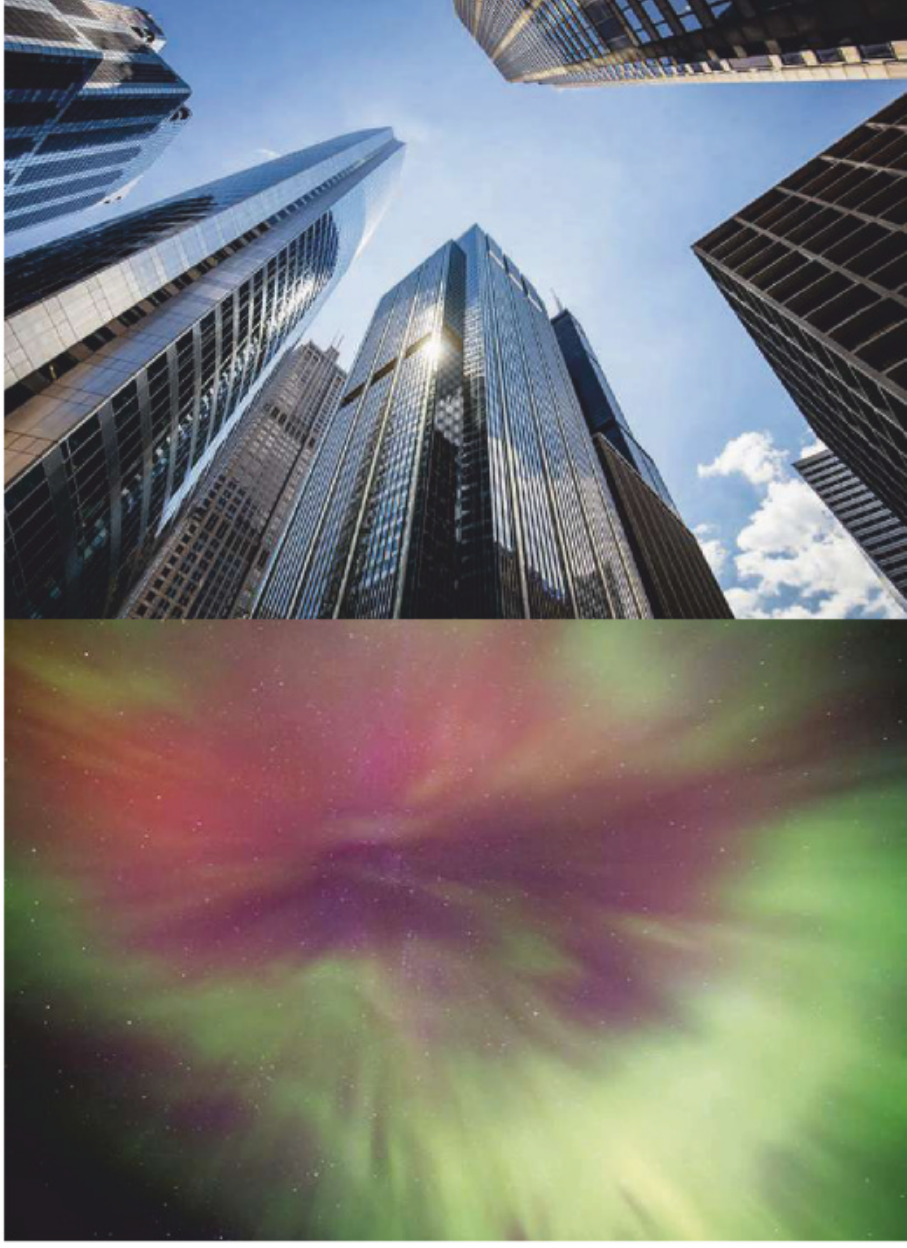
► The atoms within our atmosphere dictate the colours of the aurora. When an electron hits an atmospheric atom, it transfers some of its energy over. This releases a flash of light, the colour (or more technically, the frequency) of which depends on how much energy it transferred over. Counter-intuitively, bigger solar storms that deposit more energy in the magnetosphere result in more red and purplish-pink colours which is actually lower energy light than the blue end of the spectrum. This is due to the changing air density in the atmosphere and the vagaries of atomic physics.

Atoms have various 'energy levels' available to them, and so can absorb different amounts of energy from the incoming electrons. The same type of atom will have the same fixed energy levels. That is, every single oxygen atom will absorb the same amounts of energy to reach its 'excited' states, which means that the light released from oxygen will always be of the same frequency. In this way the aurora has characteristic colours. The common green is given off by oxygen at altitudes around 100–150km up. Oxygen has another excited state which releases red light, but only at altitudes around 200–250km up where the atmosphere is much less dense. The blue, violet and pink colours are released by nitrogen molecules, and the nitrogen atoms emit a turquoise-green that may be obscured by the bright oxygen green. Hydrogen gives out a pink-hued crimson. These atoms are generally lower in the atmosphere and so in more energetic displays these colours can be seen at the bottom of a green band of aurora.

All shapes and sizes

The aurora can take many shapes and forms. There is infinite variety in the twists, the depths, the rays, the colours and the brightness. When scientists started making systematic observations it made

▼ **Purple haze: atoms within our atmosphere dictate the vivid colours, such as violet, which can be seen under a green band**



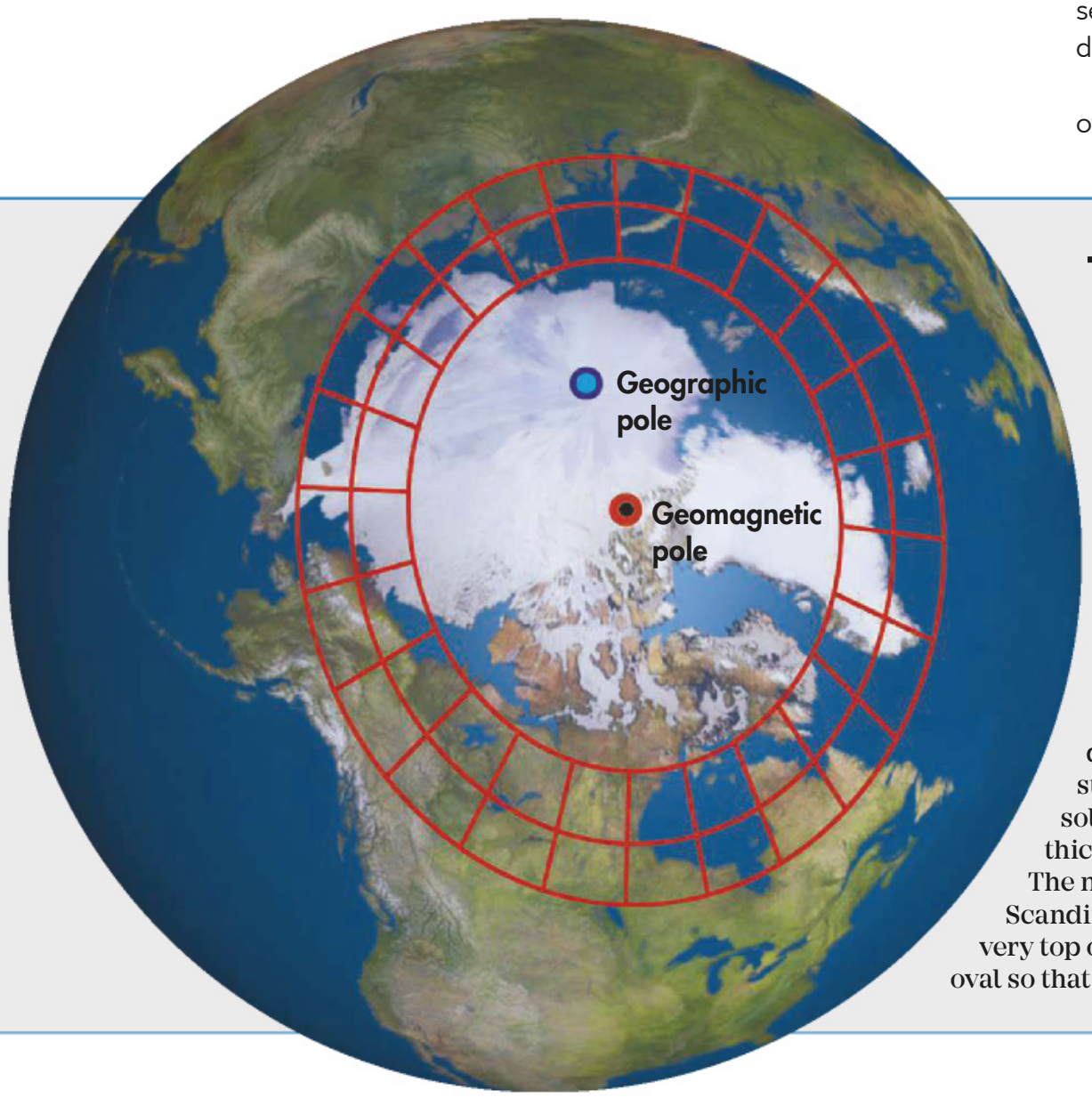
► **As you look up at skyscrapers they appear to converge in the same way as the coronal aurora**

sense to classify the aurora they were seeing into various types and subtypes for ease of comparison. The Norwegian mathematician and early auroral photographer Carl Størmer published the first system of auroral classification in 1930 in the *Photographic Atlas of Auroral Forms*, which was later updated for the *International Aurora Atlas*, released in the 1960s.

Classification was by five main characteristics – condition, structure, form, brightness and colour. Form is often the most obvious. The aurora may be discrete, appearing as an arc or a band, or diffuse like a patch of light or a veil across the sky. Or it may be rays coming down. The aurora's condition was defined as whether it was active, quiet, pulsating or coronal. Active displays have fairly fast, obvious movement, while quiet displays move only very gradually, like the clouds drifting almost imperceptibly across the sky. Pulsating displays pulse in brightness, and coronal displays burst directly overhead. Structure assessed the homogeneity of the form – was it smooth and regular or lined with horizontal striations or vertical rays? Brightness was an index giving an estimation of the green oxygen emission. Colour was split into classes indicating whether the aurora was dominated by red and green or blue and purple.

Researchers these days recognise that there are really only two main forms of aurora: the arc (discrete), and the patchy, pulsating aurora (diffuse). These are created by fundamentally different physical processes. Whereas arcs are caused primarily by electrons being accelerated into the atmosphere when Earth's magnetic field, stretched out by the solar wind, reconfigures itself, the dimmer pulsating aurora is thought to be caused by waves of charged particles scattering electrons into the atmosphere. Conversely, several of the old-style classifications are simply different ways of looking at the same thing.

Imagine watching an auroral display. The 'type' of aurora you see depends on where the activity is ►



The aurora oval

Aurora hunters track the oval to see where the lights might appear

Auroral activity occurs in a ring (or, in fact, an oval) centred on Earth's magnetic poles. The footprint of the oval, where electrons are accelerated down into the atmosphere, is determined by the changes in the magnetic structure of Earth's magnetic field caused by the solar wind. The auroral oval changes in diameter and thickness with changes in the strength of the solar wind. The northern auroral oval generally sits over northern Scandinavia, Iceland, Greenland, Canada, Alaska and the very top of Siberia, but big 'solar storms' can widen the oval so that aurora can be seen much further south.

▸ happening relative to you. Mostly, what you will see is an arc or band, or a number of arcs. A single, wide band viewed from underneath would look like an arched line in the sky. Multiple twisted, rayed bands viewed from a distance look like curtains; but were you to look up from below, it would take the appearance of a corona, like a starburst overhead with the rays meeting above you. It's not a new type of aurora; it's perspective. Think about walking through a city of skyscrapers. As you look up, the tall buildings around you appear to converge to a zenith. Then cross the river, or take a boat ride from the quay, and look back to where you walked. Now the skyscrapers have a flattened, more regular form. The individual buildings look like rays and their different heights give the city a wavy edge. It is the same city, just a very different view.

Clues about space

The shapes and structures of the aurora are not merely interesting and beautiful, they tell us about what is going on out in space. "Intensity, colour, and auroral forms are all important characteristics of aurora for scientists," says Dr Jennifer Carter, a magnetospheric physicist at the University of Leicester. "Scientists can use large-scale movements of auroral phenomena to understand how the ionosphere and the more distant magnetosphere interact."

The unpredictable, chaotic auroral movement arises because the aurora is a plasma – an electrically charged gas. Plasmas are notoriously wily and dynamic, the charged particles' movements creating feedbacks and instability. The unstable nature of plasma explains some of the erratic movement of aurora, particularly during more energetic displays. Rayed structure is related to charged particles travelling down magnetic field lines into the atmosphere. "Relative intensity between different aurora colours depends on the composition of the atmosphere and the energy of the incoming particles," says Carter.

That night I watched the aurora from the boat heading towards Tromsø, the display was quiet and the pale grey-green bands twisted languidly in the icy air. But I knew that with a little more of a kick from the Sun, the next time I stood there to watch, it could be very different.

Dr Melanie Windridge is a plasma physicist, speaker and author of *Aurora: In Search of the Northern Lights*

Types of AURORA

Over the years, astronomers have created many names to describe the changing shapes of the aurora. Displays often feature several of these forms combined together to create a truly stunning show. And just as no two aurora are the same, neither are any two sightings of the same aurora, as the shape a display appears can often vary dramatically depending on where you are in relation to the lights in the sky.

△ Curtains

Curtains are a common form of rayed band viewed from a distance, which takes a hanging, wavy appearance. They may also be referred to as drapes or draperies, particularly in historical accounts.

△ Arcs

An arc is defined as a simple curve of light with a smooth lower border. Auroral displays often start as an arc. They can stretch thousands of kilometres horizontally, hundreds of kilometres upwards, but are only a few tens of kilometres thick.

◁ Bands

A band is similar to an arc — indeed it is now recognised as a form of arc — but with an irregular, wavy lower border rather than a smooth one. They may look serpentine in structure, curving and twisting.

△ Rays

Rays are shafts of luminosity coming down from above, or they are sometimes described as pillars of light stretching upwards. Rayed structure can also be seen in the other auroral forms, such as striations seen in an arc or band. When the aurora is more active these rays can appear to move or pulse in the band.

△ Patches

Patches are regions of diffuse, less concentrated glow that appears in blobs and may pulse in brightness. Patchy pulsating aurora is much dimmer and less common than the arc forms of aurora, and the generation mechanism is different. Electrons are scattered into the atmosphere by a plasma wave called a whistler.

◁ Coronae

Named after a crown, coronae are multiple rays converging to a zenith above the viewer, appearing as a large starburst-type formation overhead. The corona is widely considered to be the most impressive type of aurora, and they occur during strong overhead activity.

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The Sky Guide

FEBRUARY 2020

IN THE SHADOW OF CALLISTO

Jupiter's outer Galilean moon casts its shadow on the gas giant's disc

VENUS AT SUNSET

Wrap up warm to catch Venus with a crescent Moon

TRICKS OF THE LIGHT

Get to know the Moon's clair-obscur effects

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ✦ Mercury at greatest elongation
- ✦ Hot on the trail of comet C/2017 T2 PanSTARRS
- ✦ Can you spot the green flash of Venus?

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

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FEBRUARY HIGHLIGHTS

Your guide to the night sky this month

Saturday 1

The clair-obscur effect known as the Face in Albategnius is visible this evening on the Moon. It is the profile of a face cast by a rim shadow onto the floor of crater Albategnius. See if you can spot it.

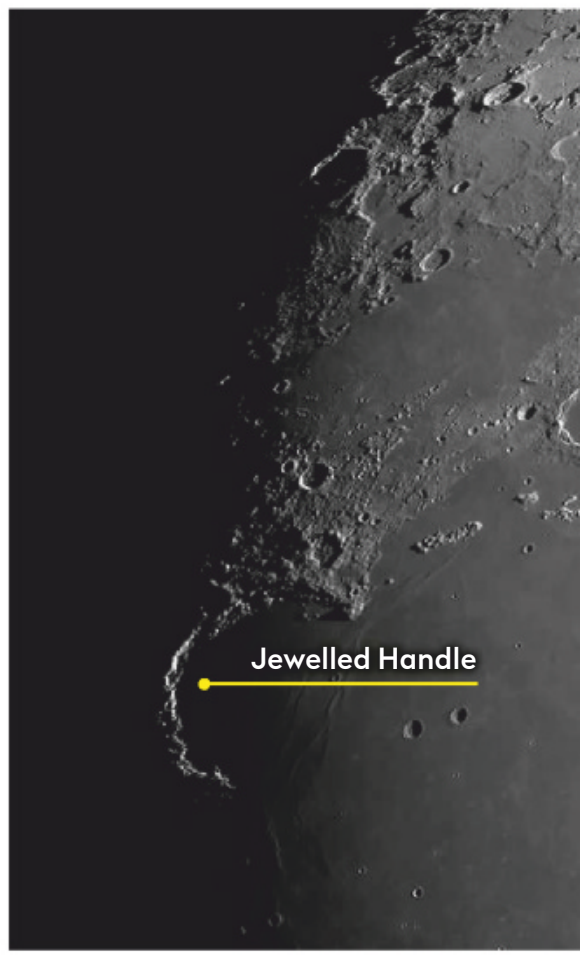
Sunday 2

Another clair-obscur effect, known as Plato's Hook, is visible tonight. Look for a pointed shadow cast across the floor of the lunar crater Plato. The shadow is supposed to appear curved.

Tuesday ▶ 4

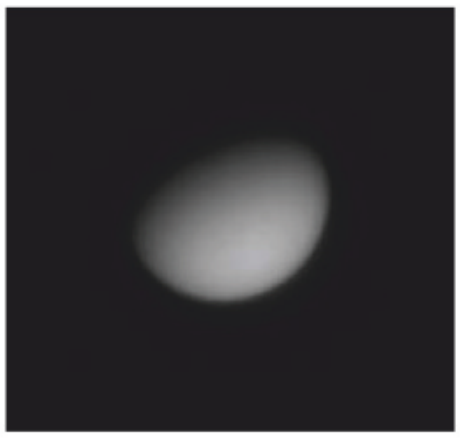
This morning's 69%-lit waxing gibbous Moon lies 3.7° from mag. +0.8 Aldebaran, with the Moon just north of the Hyades open cluster at this time.

The lunar clair-obscur effect known as the Jewelled Handle will be visible around 02:00 UT.



Thursday ▶ 6

This morning's 85%-lit waxing gibbous Moon sits 2° south of the fifth magnitude open cluster M35 in Gemini. The mag. +2.8 star Propus (Eta (ε) Geminorum) is occulted just after 02:00 UT, reappearing around 03:00 UT.

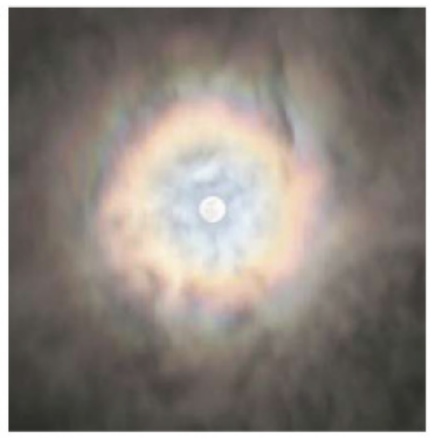


◀ Saturday 8

The brilliant planet Venus appears to be growing as it gets closer to Earth. It has now reached the point when it appears 15 arcseconds across through a telescope and shows a 70%-lit phase.

Sunday ▶ 9

This evening the bright star to the south of the full Moon is mag. +1.3 Regulus (alpha (α) Leonis). This full Moon occurs near to perigee, the first of several such 'supermoons' in 2020.

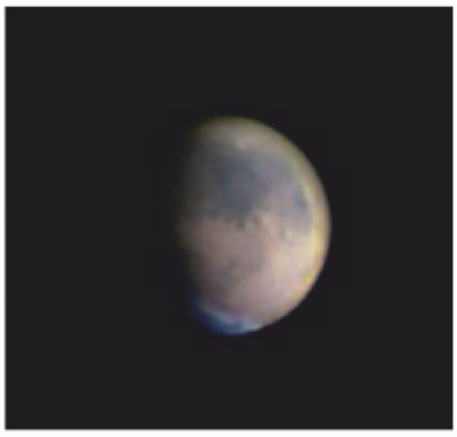


Tuesday 11

Mag. +8.0 Neptune is 2.3 arcminutes from mag. +4.2 Phi (φ) Aquarii.

Tuesday ▶ 18

This morning's 25%-lit waning crescent Moon sits 3.2° from mag. +1.2 Mars.

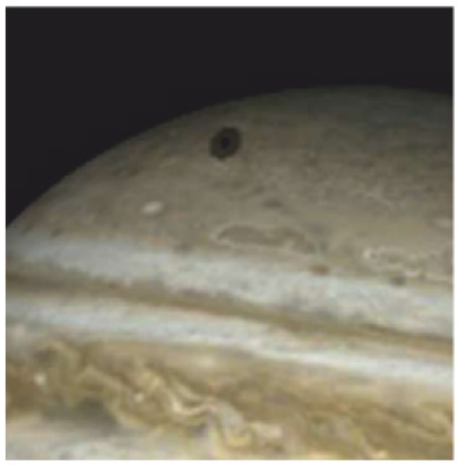


Wednesday ▶ 19

This morning it's the turn of mag. –1.8 Jupiter to get a visit from the Moon. At 07:00 UT the 17%-lit waning crescent sits 6.5° west of Jupiter.

Wednesday 26

This morning sees the shadow of the outermost Galilean Moon Callisto pass across the face of Jupiter. The shadow transit starts at 06:30 UT and ends at 09:38 UT. See page 47.



Thursday ▶ 27

The first of two evenings when the crescent Moon lies close to the planet Venus. This evening it's a 14%-lit waxing crescent Moon, which lies 6.2° to the south of mag. –4.1 Venus.

PETE LAWRENCE X 9

Wednesday
5 This evening's Moon will be showing our excellent Moonwatch target, the Lacus Excellentiae. See page 52.

Friday
7 This morning the 93%-lit waxing gibbous Moon passes 24 arcminutes north of mag. +3.5 Wasat (Delta (δ) Geminorum).

Monday ▶
10 The planet Mercury reaches greatest eastern elongation today, separated from the Sun by 18.2° and visible in the evening sky.

Friday
21 This morning, 10th magnitude comet C/2017 T2 PanSTARRS can be found between the open clusters Stock 2, the Muscleman Cluster, and NGC 743, both in Cassiopeia. See page 53.

Sunday
23 The Moon reaches its new phase today, an ideal time to take our Deep-Sky Tour on page 56. This month we're looking at objects near to the border between Cancer and Hydra.

Friday
28 This evening the now 21%-lit waxing crescent Moon sits 12.3° southeast of bright Venus.

Family stargazing

If the weather is clear during February's first half, it's a good time for young eyes to try and spot the planet Mercury. Conditions are best during February's first 10 days and you'll need a fairly flat horizon to the west-southwest. Make sure the Sun has set before looking. After sunset, look for the brighter planet Venus higher up in the southwest. It's so bright it should be easy to spot. Use our diagram on page 48 and start looking for Mercury. It'll be dimmer, lower and set against a bright twilight background. Few people have seen Mercury with the naked eye. www.bbc.co.uk/cbeebies/shows/stargazing

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

THE BIG THREE

The three top sights to observe or image this month

DON'T MISS

Clair-obscur EFFECTS

BEST TIME TO SEE: All mentioned effects occur in the first week of February at the stated times.

There are many clair-obscur effects visible on the Moon; a play of shadow and light which appear as something familiar through the eyepiece. Examples include the **Lunar X** and **V**, separate effects which create giant floating letters on the lunar terminator near first quarter.

With such a variety of effects, hunting them down adds a new dimension to lunar discovery, especially for youngsters.

Most effects require specific timing. Some last for days and are easy to see. Others last for a few hours and are more challenging. In order to see short-lived effects, the terminator must be positioned correctly when the Moon is above the horizon. The weather needs to be clear too.

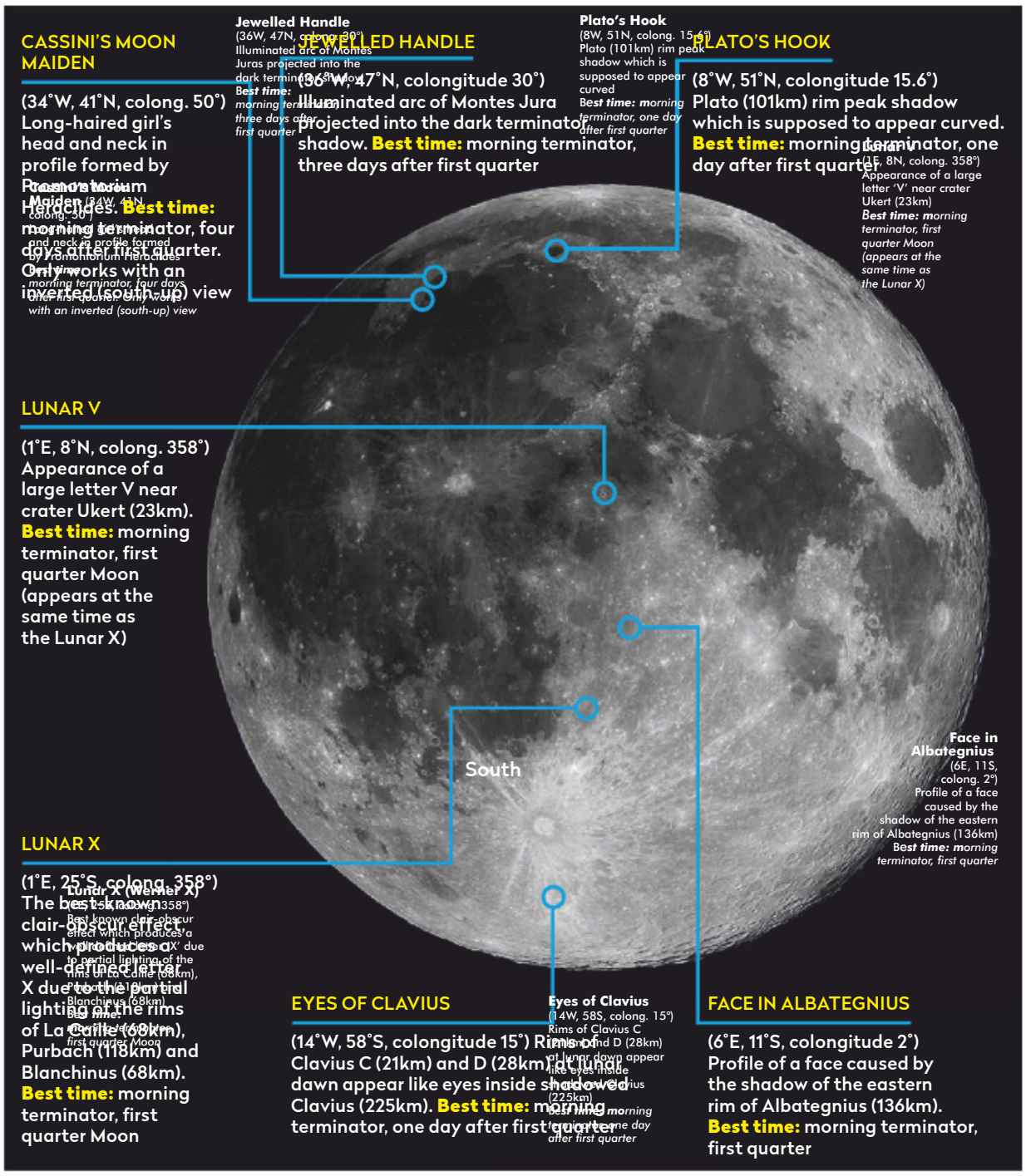
The terminator position is given by a value known as selenographic colongitude, defining the location of the morning terminator in degrees west of the Moon's prime meridian. The values are 0° at first quarter, 90° at full Moon, 180° at last quarter and 270° at new Moon.

The lunar X and V occur at colongitude 358°. Both appear at 11:05 UT on 1 February, but this is when the Moon's rising in daylight. The **Face in Albategnius** (colongitude 2°) is better placed, occuring when the eastern rim of crater Albategnius casts a shadow resembling the profile of a face. It's visible on 1 February at 19:00 UT.

Plato's Hook (colongitude 15.6°) is a curiosity. It is caused when rim shadows inside crater Plato appear to cast a curving, hook shadow where you'd expect the shadow edges to be straight. Take a look for yourself on the evening of 2 February at 21:50 UT. On the same date the **Eyes of Clavius** (colongitude 15°) occurs when the rims of Clavius C and D become illuminated by the lunar dawn before the floor of the giant crater Clavius in which they sit. The Eyes are visible on 2 February at 20:40 UT.

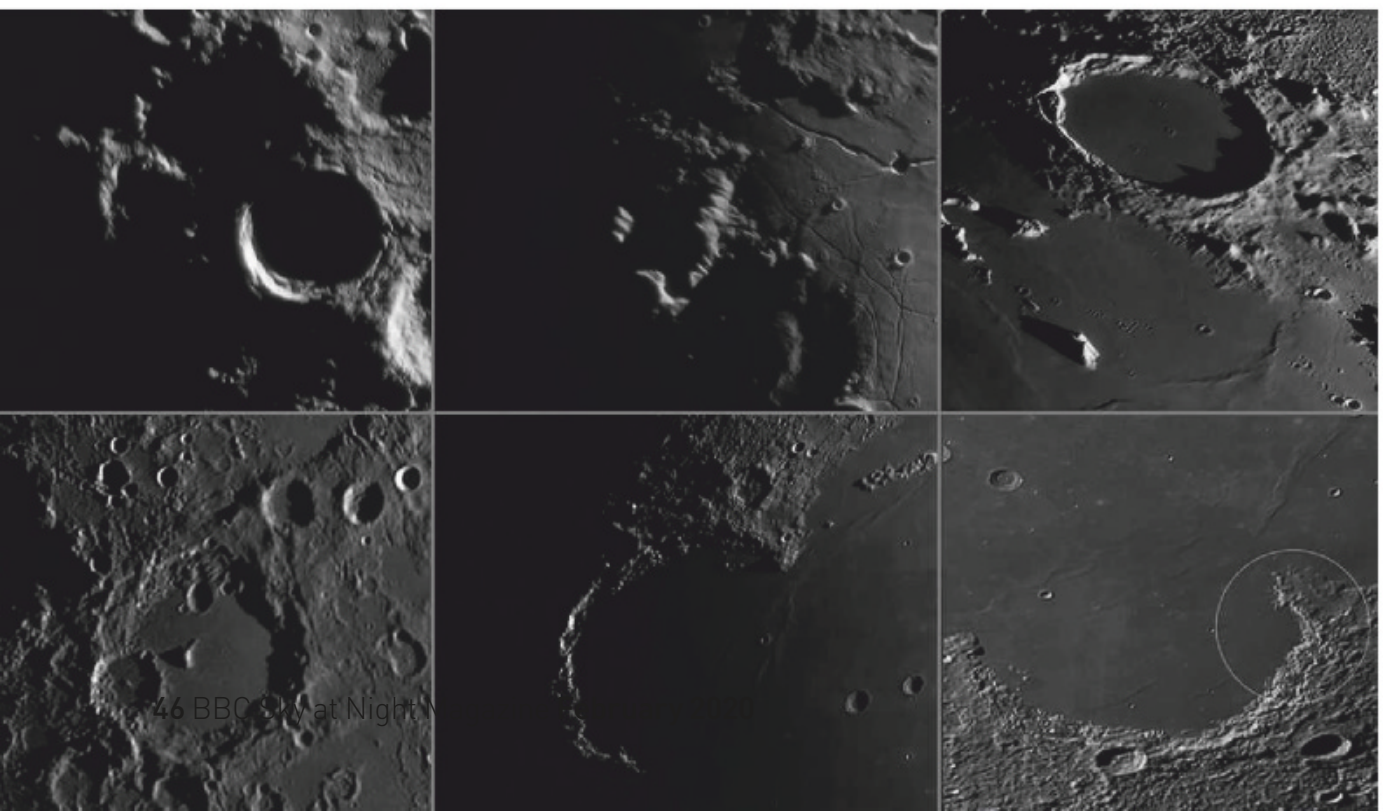
An easy effect to see is the **Jewelled Handle** (colongitude 30°). This occurs when peaks of the semi-circular Jura mountain range catch the lunar dawn's light. Look for this on 4 February, around 02:15 UT.

On 5 February at 17:40 UT, **Cassini's Moon Maiden** (colongitude 50°) is visible at the southern end of Sinus Iridum, where the profile of a woman looks out across the bay.



▲ **Optical illusions: where and when to observe the Moon's clair-obscur effects**

ALL PICTURES: PETE LAWRENCE



◄ **Upper row, left to right: Lunar X, Lunar V, Plato's Hook. Lower row, left to right: Face in Albategnius, the Jewelled Handle, Cassini's Moon Maiden (south-up view)**

Callisto's shadow transit across Jupiter's disc

BEST TIME TO SEE: 06:40–09:30 UT on 26 February. Begin viewing from 06:00 UT

Gas giant Jupiter has many moons. Most are pretty small and too faint for amateur equipment to record. Only four are readily accessible to amateurs, the so-called Galilean moons first identified as satellites by Galileo Galilei in 1610. In order of distance from Jupiter, these are Io, Europa, Ganymede and Callisto. All of the Galileans have orbits that are close in orientation to the equatorial plane of Jupiter.

Jupiter's 3.1° axial tilt is small compared to the 23.4° of Earth. From Earth, Jupiter's Galilean moons appear to move back and forth around the planet in narrow ellipses. Narrow though they are, the greater distance of Callisto means that its orbital ellipse is wide enough for it and its shadow to miss Jupiter's disc for most of the time. That is until Jupiter approaches an equinox, something it does twice in its 11.8-year orbit.

Separated by approximately six years, the next Jovian equinox occurs in 2021 and in the months before and after this time, it is possible to see Callisto and its shadow transit Jupiter's disc.

▲ **Moon on the move: the progress of Callisto's shadow transit on the morning of 26 February, showing an inverted view with south up**

Starting at 06:40 UT on 26 February, against the backdrop of a brightening dawn twilight sky, Callisto's shadow can be seen crossing Jupiter's disc. It is possible to see Jupiter in daylight, but the fact that it can be seen against a darker sky from 06:00 UT, and Jupiter sits between Mars and Saturn will give you something to lock on to.

Stay with the planet as the sky begins to lighten and you'll see the large shadow begin its crossing. There will be further transits visible over coming months, but with the vagaries of the British weather it pays to take every opportunity that comes along.

This transit continues until around 09:30 UT. Sunrise from the centre of the UK is just after 07:00 UT.

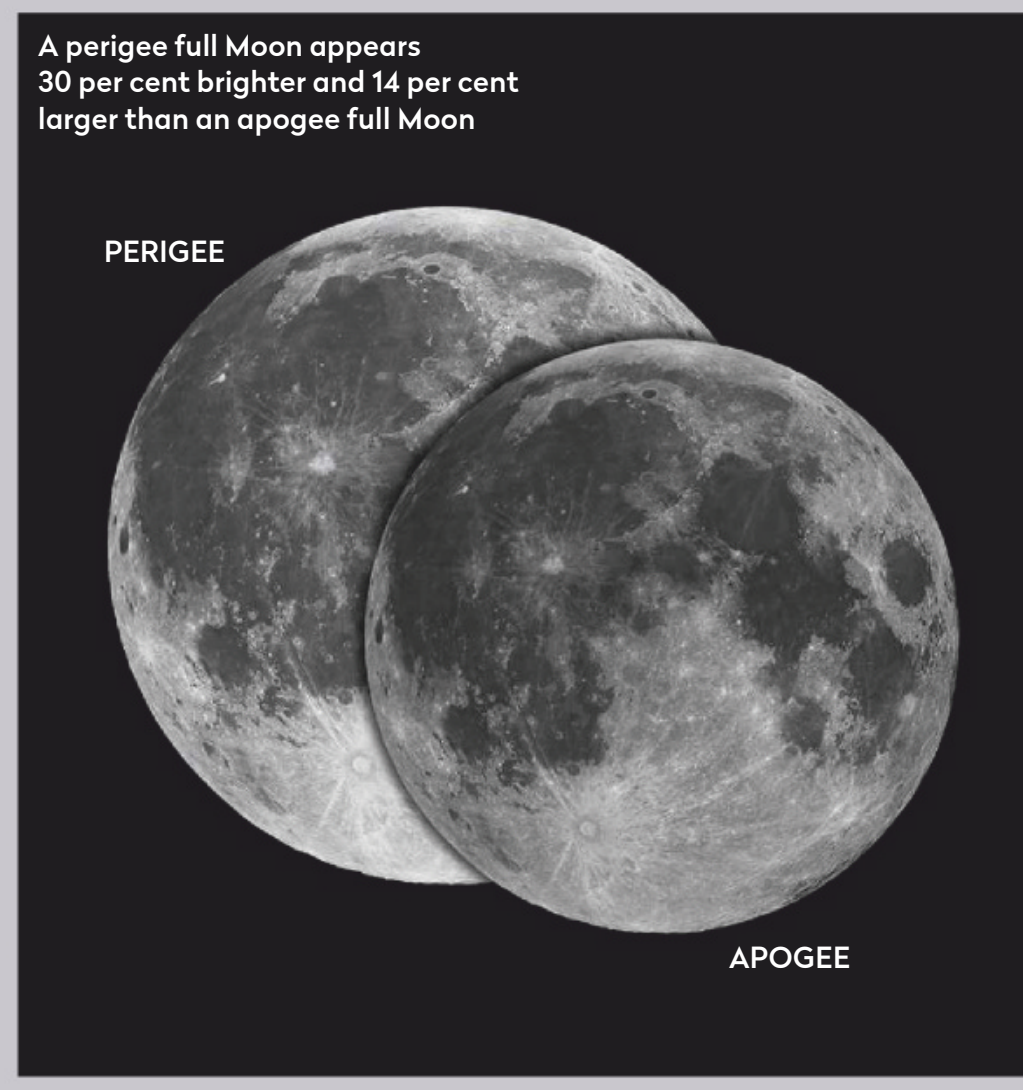
Perigee full Moons

BEST TIME TO SEE: The night of 8 February into the morning of 9 February

The lunar orbit is elliptical, meaning the Moon's physical distance from Earth is constantly changing. The two orbital extremes are known as perigee (closest to Earth) and apogee (farthest from Earth) and each occurs once a month.

The timing of full Moon and lunar perigee or apogee are not in sync but drift in and out of phase over the course of many lunar orbits. During certain months, full Moon occurs closer to perigee than others. Once one occurs, the next two will typically be close to perigee too. The first of these 'supermoons' for 2020 occurs on 9 February. On this occasion full Moon is at 07:34 UT, with lunar perigee on 10 February at 20:32 UT. Next month full Moon occurs on 9 March at 17:48 UT, with perigee on 10 March at 06:34 UT. Finally, in April full Moon occurs on 8 April at 03:36 BST and perigee on 7 April at 18:10 UT.

The visual impact of a perigee full Moon compared to an apogee full Moon is that the full Moon appears approximately 30 per cent brighter and 14 per cent larger. However, in reality, as previous and subsequent full Moons to the perigee full Moon are near to perigee themselves, the difference from one month to the next is barely noticeable.



PICK OF THE MONTH

Mercury

Best time to see: 10 February, 30 minutes after sunset
Altitude: 11°
Location: Aquarius
Direction: West-southwest
Features: Phase, subtle markings
Recommended equipment: 75mm or larger

Mercury reaches greatest eastern elongation on 10 February when it will appear east of the Sun separated by 18.2°. This places it in the evening sky where it joins its Solar System neighbour Venus. Unlike Venus, which reaches greatest eastern elongation on 24 March, Mercury's greatest separation from the Sun means that it cannot be seen against truly dark skies. Consequently, you'll need to have a flat, uncluttered west-southwest horizon and clear skies to have the best chance of spotting this elusive world in February. Venus by contrast will appear much higher in the sky after sunset.

Mercury is very well placed at the start of the month when it will appear bright and well separated from the Sun. On the 1st it shines at mag. –0.9. By the time it reaches greatest elongation on the 10th, although its magnitude will have dropped to –0.4, its separation from the Sun will mean that it will set around 110 minutes after sunset. Separation remains good for much of February, but Mercury's brightness will continue to drop and this will make it harder to see. It'll probably be lost soon after 20 February when it shines at mag. +2.4, but sets just over an hour after the Sun. Inferior conjunction occurs on 26 February.

Getting a steady telescopic view of Mercury is quite tricky unless you're set up to view it in daylight. Its inevitably low altitude after sunset means it's subject to the vagaries of poor atmospheric seeing. At the start of February, the planet presents a tiny 5 arcsecond gibbous disc, 83%-lit. At elongation on 10 February, the phase will appear at 50% illumination and the disc will be slightly larger at 7 arcseconds. On the 20th, the dimmer planet will present an 8%-illuminated crescent, 9 arcseconds across.

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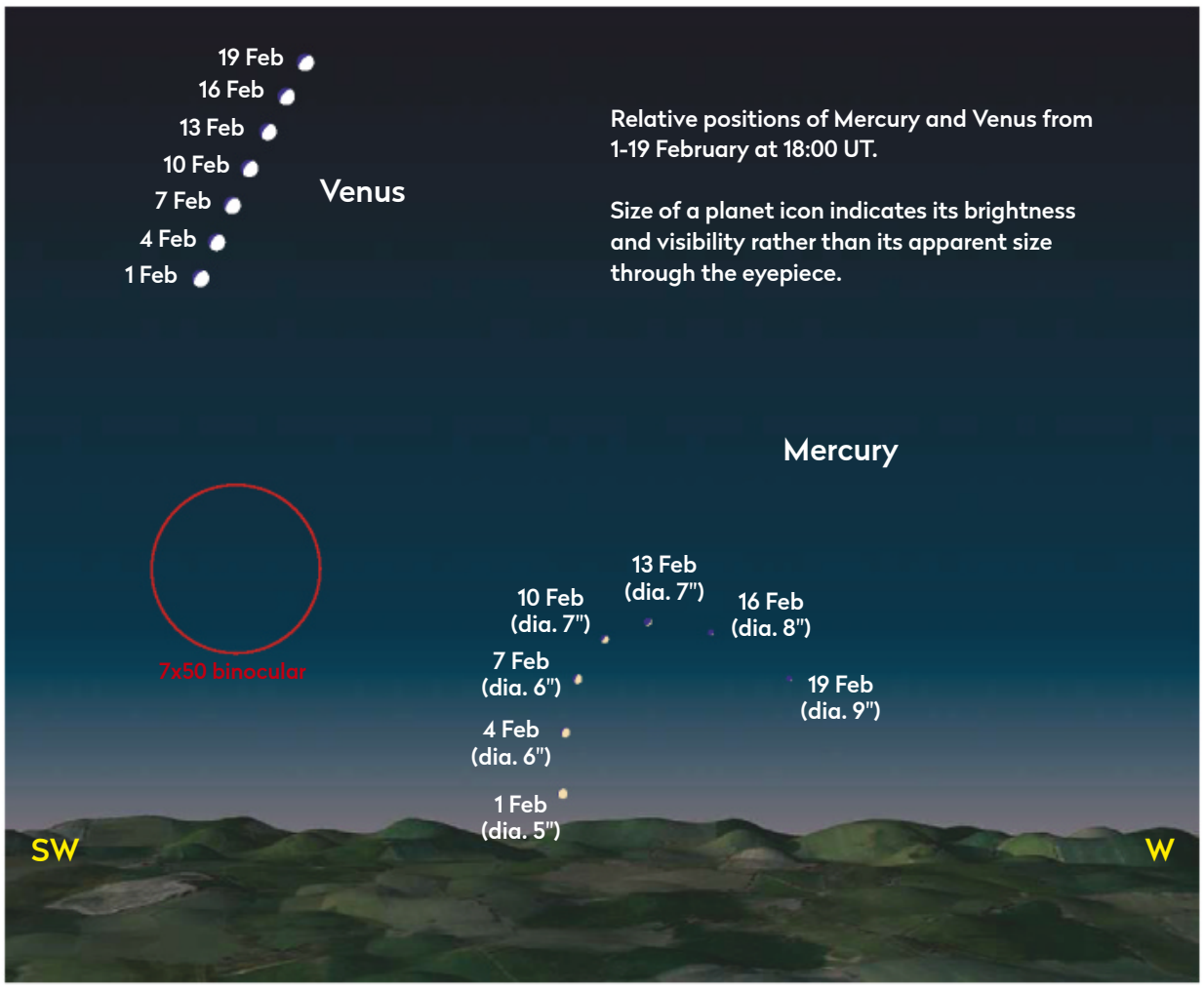
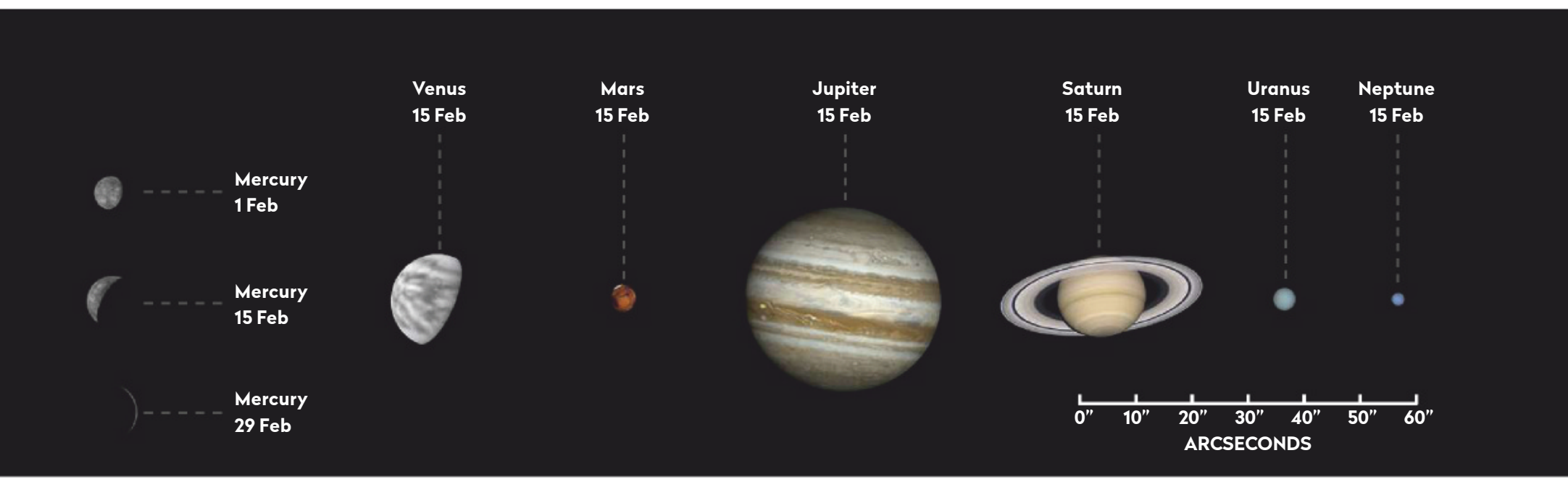


▲ **Second sight: the positions of Venus and Mercury from 1–19 February. Bright Mercury is particularly well placed for observing at the start of the month when it is mag. –0.9**

The planets in February

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Venus

Best time to see: 29 February, shortly after sunset
Altitude: 34˚
Location: Pisces
Direction: Southwest
Venus is the dominant planet in UK skies, a beacon in the southwest after sunset. On 1 February, a scope will show its 73%-illuminated disc 15 arcseconds across and shining at mag. –4.0. It will set nearly four hours after the Sun on the 1st and be visible against dark skies for a couple of hours.

By the month's end, it remains visible for four hours and 20 minutes after sunset, shining at mag. –4.1. Its appearance against a dark sky will have increased to around 2.5 hours by the 29th, its altitude being about 20˚.

On the 29th, changes in the apparent size and shape of Venus will be evident through a scope. It has an 18 arcsecond disc, 62%-illuminated.

Mars

Best time to see: 29 February, 05:30 UT
Altitude: 5˚ (low)
Location: Sagittarius
Direction: Southeast
Mars is a morning planet rising a couple of hours before the Sun. It's located in the constellation of Sagittarius and never rises high above UK horizons. Its shining at mag. +1.3 and appears small through a scope. On the 29th, Mars presents a 5 arcsecond gibbous disc, 90%-lit.

Jupiter

Best time to see: 29 February, 05:45 UT
Altitude: 3.5˚ (low)
Location: Sagittarius
Direction: Southeast
The precession of morning planets continues after Mars with Jupiter. Unfortunately, as it is also located in Sagittarius, it remains too low for serious UK viewing at present. Jupiter shines at mag. –1.8 on the 29th.

Saturn

Best time to see:
29 February, 06:00 UT
Altitude: 3˚ (low)
Location: Sagittarius
Direction: Southeast
Wait long enough in the morning sky, and you'll find Saturn bringing up the rear behind Mars and Jupiter. On 29 February, when all three planets have achieved a reasonable separation from the Sun in the morning sky, they form a distinctive line low in the southeast. And it remains low too, as all three planets are currently situated along the lowest part of the ecliptic as seen from the UK. On the 29th, Saturn is mag. +1.0.

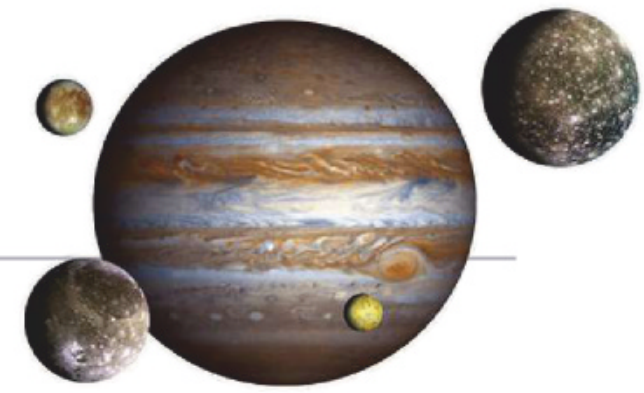
Uranus

Best time to see: 1 February
Altitude: 46˚
Location: Aries
Direction: South-southwest
Uranus is fairly well positioned at the month's start, but is west of south at true darkness. By the month's end this situation has worsened and as true darkness falls the mag. +5.8 planet will be about 20˚ lower in the sky in the southwest.

Neptune

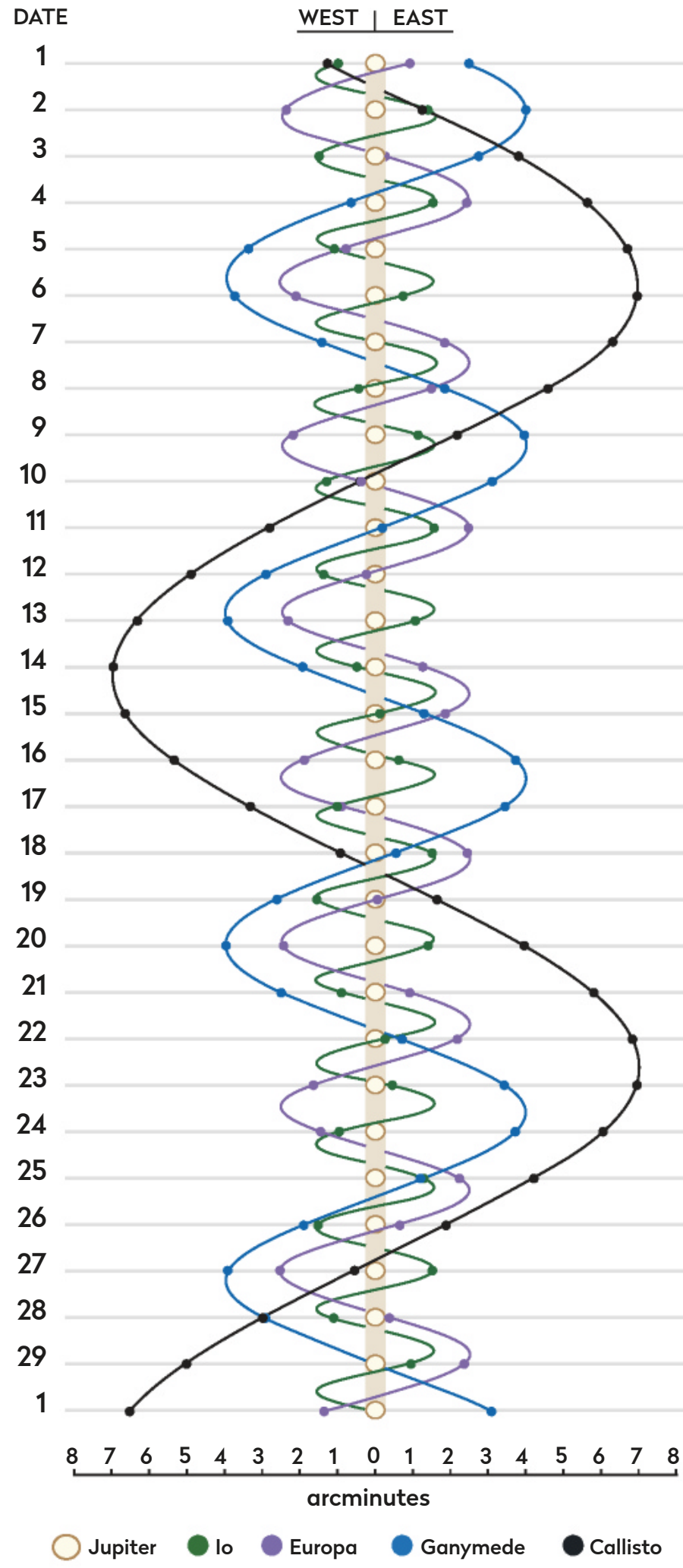
Best time to see: 1 February
Altitude: 12˚
Location: Aquarius
Direction: West-southwest
Neptune is located in Aquarius near to mag. +4.2 Phi (ϕ) Aquarii. Its position is now compromised, with the mag. +7.9 planet appearing low over in the west-southwest as darkness falls at the month's start. As the month ends twilight will have engulfed Neptune.

More **ONLINE**
Print out observing forms for recording planetary events



JUPITER'S MOONS: FEBRUARY

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 00:00 UT.



THE NIGHT SKY – FEBRUARY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- ASTERISM (Circlet)
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW (N, E, S, W, 5°)
- MILKY WAY

When to use this chart

1 February at 00:00 UT
15 February at 23:00 UT
29 February at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in February*

Date	Sunrise	Sunset
1 Feb 2020	07:56 UT	16:52 UT
11 Feb 2020	07:38 UT	17:12 UT
21 Feb 2020	07:17 UT	17:31 UT
2 Mar 2020	06:55 UT	17:51 UT

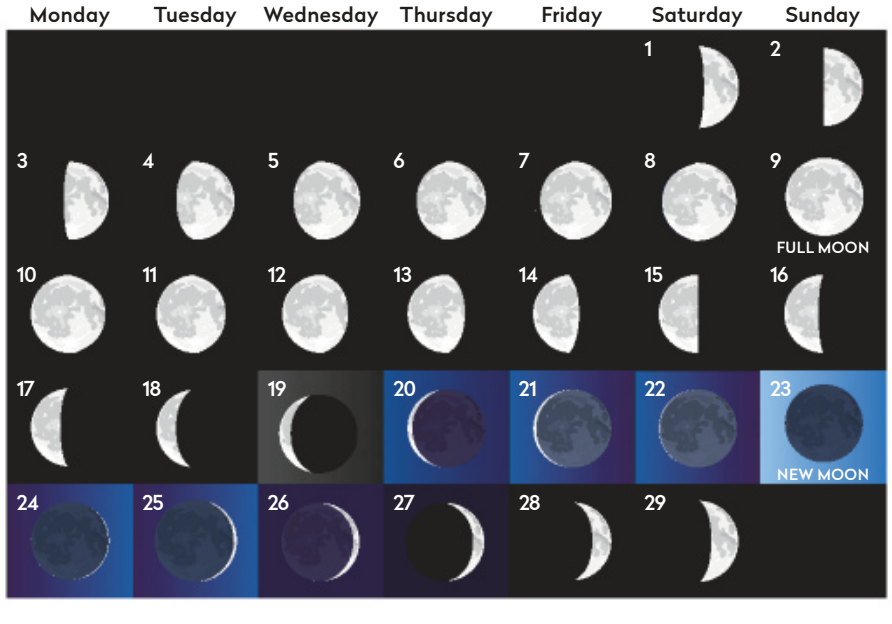
Moonrise in February*

Moonrise times

1 Feb 2020, 10:56 UT	17 Feb 2020, 03:11 UT
5 Feb 2020, 12:41 UT	21 Feb 2020, 06:49 UT
9 Feb 2020, 17:19 UT	25 Feb 2020, 08:17 UT
13 Feb 2020, 23:09 UT	29 Feb 2020, 09:17 UT

*Times correct for the centre of the UK

Lunar phases in February



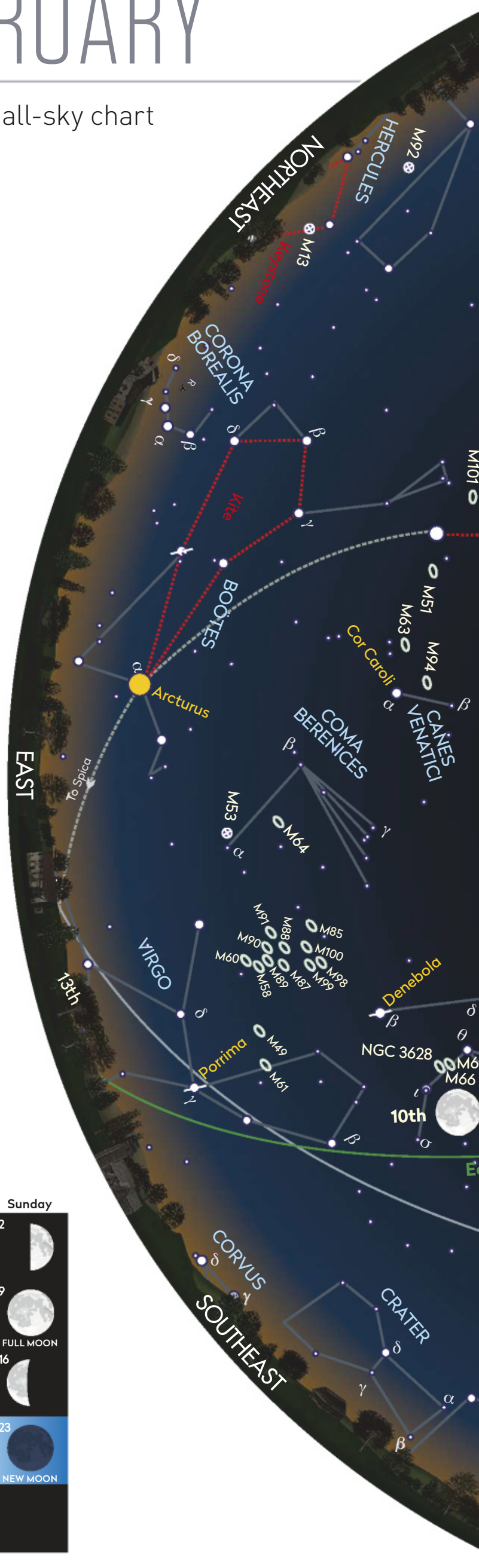


CHART: PETE LAWRENCE

NORTH
Summer Triangle
CYGNUS
M39
CEPHEUS
Alderamin
House
DRACO
M52
CASSIOPEIA
Schedar
W
M103
Double Cluster
CERTA
quare of P
NORTHWEST
M110
M31
M32
ANDROMEDA
PISCES
M33
TRIANGULUM
Hamal
ARIES
Mirphak
M34
Algol
PERSEUS
CAMELOPARDALIS
URSA MINOR
Kochab
Polaris
Thuban
Alcor
Mizar
URSA MAJOR
Plough
Dubhe
Merak
M97
M106
M82
M81
NGC 2805
23
LYNX
Capella
Kids
AURIGA
M38
M36
M37
Elnath
Pleiades
M45
TAURUS
Hyades
Aldebaran
4th
1st
CETUS
Menkar
WEST
LEO MINOR
Castor
Pollux
GEMINI
M35
Sickle
LEO
7th
M44
M105
M96
M95
cliptic
Regulus
M67
CANCER
Deep-sky tour, p56
Betelgeuse
Bellatrix
ORION
ERIDANUS
Mirror of Venus
M78
M42
Rigel
CANIS MINOR
Procyon
MONOCEROS
Winter Triangle
Sirius
CANIS MAJOR
M41
M50
LEPUS
SOUTHWEST
Celestial Equator
SEXTANS
Alphard
HYDRA
M48
M46
M47
ANTLIA
PYXIS
PUPPIS
SOUTH

MORE **ONLINE**

Paul and Pete's night-sky highlights

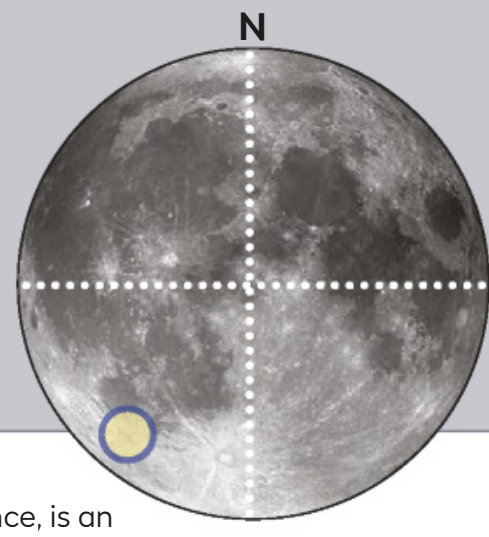
Southern Hemisphere sky guide

MOONWATCH

February's top lunar feature to observe

Lacus Excellentiae

Type: Lunar lake
Size: 150km
Longitude/latitude: 44˚ W, 35.4˚ S
Age: Between 3.2-3.9 billion years
Best time to see: Four days after first quarter (5–6 February) and three days after last quarter (18–19 February)
Minimum equipment: 10x binoculars



Lacus Excellentiae, the Lake of Excellence, is an irregular patch of medium darkness lava located immediately to the south of the larger and darker form of 380km **Mare Humorum**. Lunar lakes are lava filled regions too small to be considered seas (Maria).

From Earth, Lacus Excellentiae is reasonably close to the Moon's southwest limb and so appears to be considerably foreshortened. Seen from above, the sea would have a five-pointed star-like appearance but foreshortened its overall shape is quite hard to discern. Its lava is flat and relatively featureless, save for the intrusion of 25km **Clausius** in the west. This crater has a well-defined rim and a distinctive oval shape. However, like Lacus Excellentiae, internally there's not a lot to see, its floor being quite flat. If you struggle to see the lake, imagine a line from the southern tip of Mare Humorum toward the giant 227km crater **Schickard** to the southwest. The first half of this line, starting at the Mare Humorum end, crosses Lacus Excellentiae.

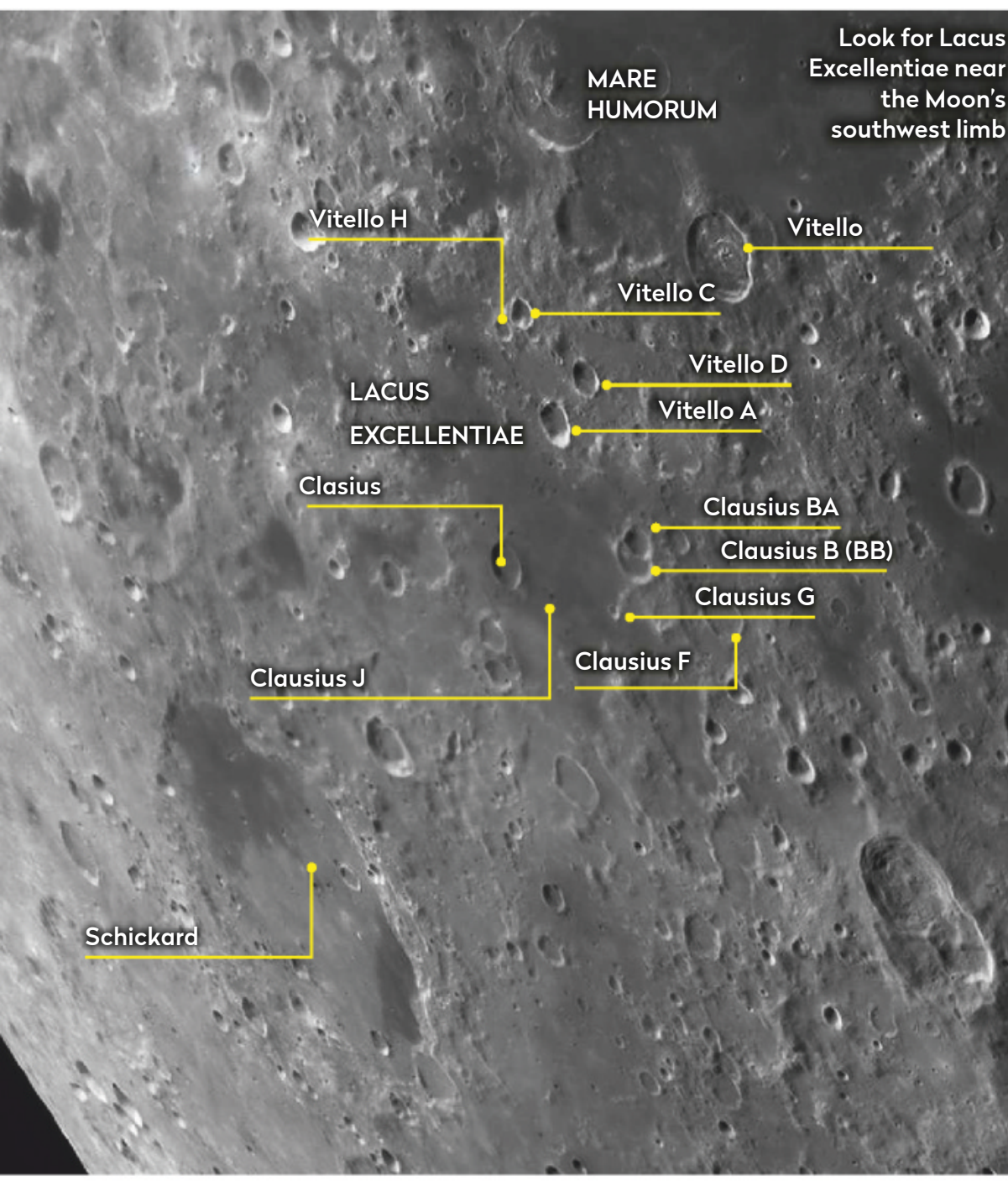
On the opposite (eastern) shore to Clausius is a pair of overlapping craters labelled as **Clausius B**. The larger, overlapped crater is sub-labelled Clausius BB. Its 23km oval form defines a ring with a flat, featureless floor. **Clausius BA** is the 17km crater which lies over BB to the north. Further southeast is the irregularly shaped rim of 26km **Clausius F**.

It's a fascinating exercise to try and trace the boundaries of Lacus Excellentiae

If you fancy a challenge, try to locate 6km **Clausius G** which can be found on the surface of Lacus Excellentiae to the southwest of Clausius B. This should be pretty easy for a 100mm telescope. Then head west across the lake towards the southern rim of Clausius. Here you'll find 4km **Clausius J**, a tougher prospect altogether which will probably need a 200mm scope or larger to pick out convincingly.

It's a fascinating exercise to spend time looking at the lava of Lacus Excellentiae and trying to trace its boundaries against the surrounding highland region. To the north, things get quite messy with many patches of lava having 'puddled' within low-level highland depressions. This is the transition region between highland areas and Mare Humorum. An interesting group of four similar looking craters can be found to the north of the lake; **Vitello A** (21km), **C** (14km), **D** (18km) and **H** (12km). Three appear quite irregular in shape, appearing like regions of the lunar surface have been scalloped away. The exception is **Vitello H** which does at least have a degree of symmetry to its appearance. All four have flat floors with no evidence of any central mountain peaks.

On a side note, Lacus Excellentiae was the location where the SMART-1 lunar orbiter ended its days on 3 September 2006. Originally launched on 27 September 2003, ESA's Small Missions for Advanced Research in Technology-1 spacecraft was deliberately brought down in the lake at the end of its mission life. The resulting impact was visible using ground-based telescopes and helped further our understanding of the Moon, its flash serving as a simulated meteor impact providing a source for spectroscopic analysis.



PETE LAWRENCE X 5

COMETS AND ASTEROIDS

Will Comet C/2017 T2 PanSTARRS reach naked-eye brightness in spring 2020?

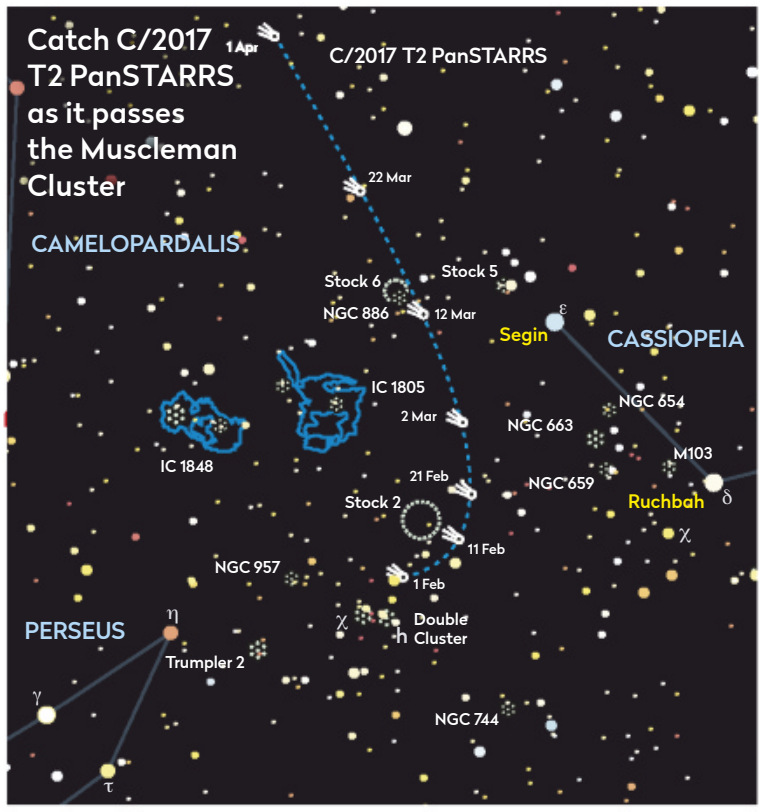
We've been reporting on comet C/2017 T2 PanSTARRS over the past months based on an early prediction that it may reach naked-eye brightness during May 2020. As the year has now got well underway, it's time to revisit the comet to assess whether it will live up to expectations.

C/2017 T2 PanSTARRS was discovered on 2 October 2017 by the PanSTARRS 1 telescope facility on Haleakala, Hawaii. Its discovery magnitude was +19.9, the object being 9.3 AU from the Sun at that time. Perihelion occurs at the start of May when the comet will be at a distance of 1.6 AU from the Sun. Closest approach to Earth occurred last year, on 29 December 2019.

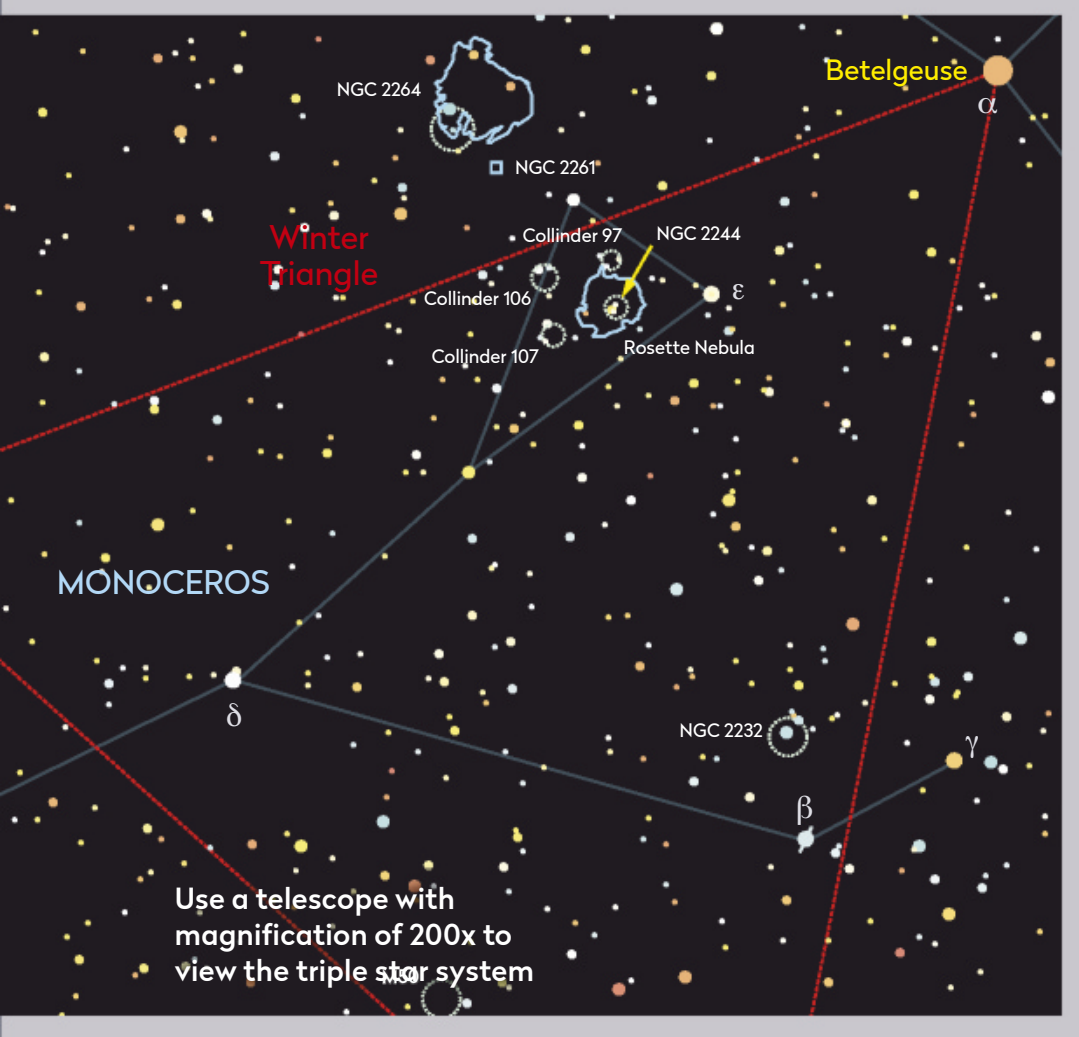
Speculation surrounded the comet's brightness at perihelion thanks to a rapid brightening rate observed intermittently when T2 PanSTARRS came out of solar conjunction in summer 2019. Early indications suggested it could creep into naked-eye territory during the spring of 2020 which, combined with a good position for the UK, would be an exciting prospect.

Now, with lots of observations having been made, it is possible to make a realistic prediction about how the comet may appear at peak brightness. Unfortunately, it looks as if the rate of brightening has slowed and a naked-eye spring appearance is now unlikely. Instead it is likely to be a ninth magnitude binocular object, quite small in appearance.

This month sees T2 PanSTARRS swing around the Muscleman Cluster, Stock 2, in Cassiopeia. At around mag. +10.0, a small scope is recommended to spot it. Its position will remain favourable at least throughout the period up to and beyond perihelion. The comet will pass through the north polar region of the sky close to the Pole Star, Polaris as it reaches peak brightness.



STAR OF THE MONTH



Beta Monocerotis, a triple wonder

Monoceros is a large and ill-defined constellation in the area defined by the Winter Triangle and the region to the east. The Winter Triangle is an asterism formed by the three bright stars Procyon, Sirius and Betelgeuse.

None of the stars in Monocerotis are bright. Despite its designation, mag. +3.9 Alpha (α) Monocerotis isn't the brightest, this position goes to mag. +3.7 Beta (β) Monocerotis. Lacking any distinctive shapes, the best way to locate Beta is to use two of the Winter Triangle stars, Betelgeuse and Sirius. Locate the region half way along the line formed by this pair, where you will find two dim stars separated by 3.5°. The two faint stars are Beta Monocerotis to the east and mag. +4.0 Gamma (γ) Monocerotis to the west.

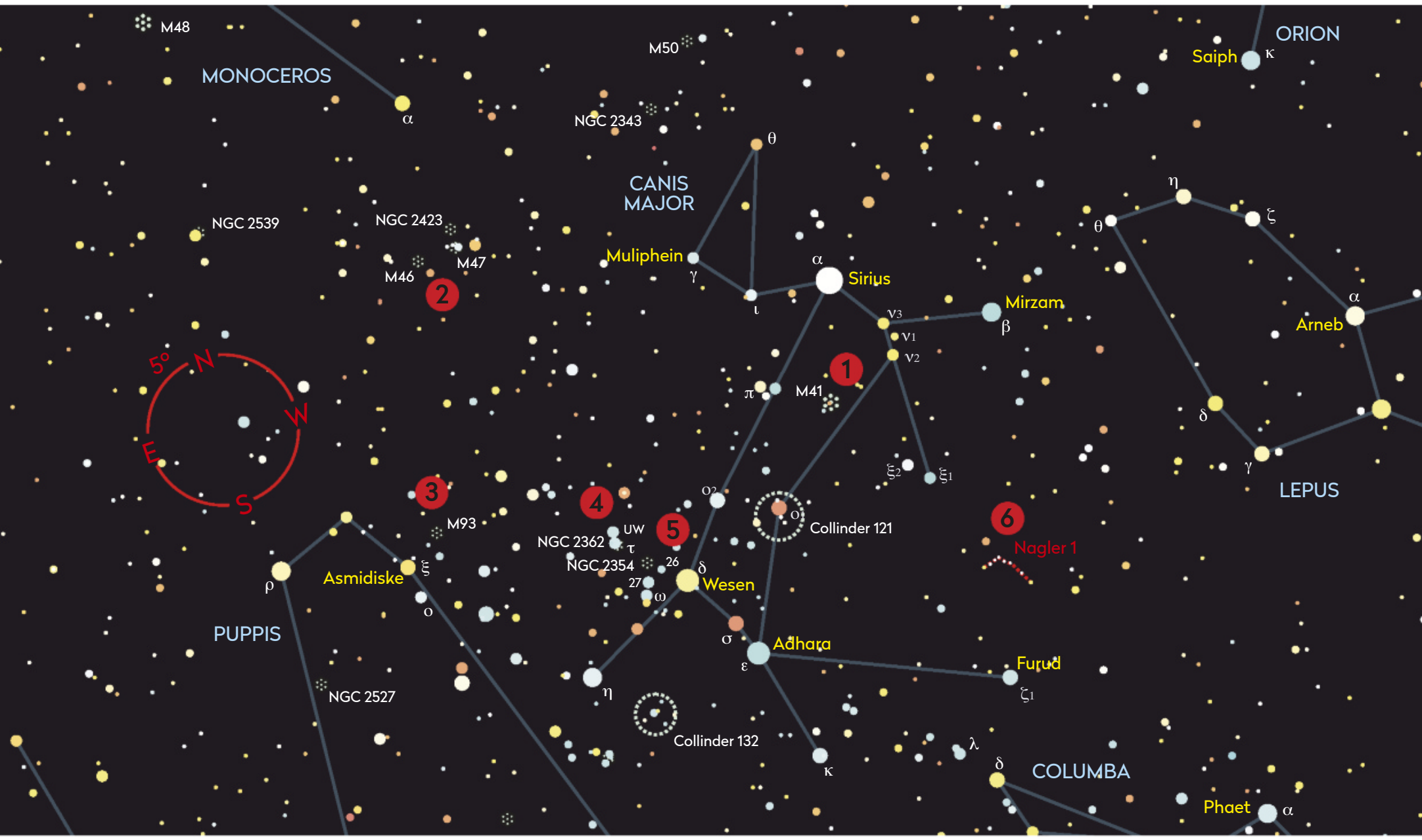
Beta Monocerotis was discovered by William Herschel in 1781. It's only when a scope is applied to the star that its beauty shines out. Beta Monocerotis is a triple system, located 700 lightyears from Earth. Through the eyepiece its pale-yellow components describe a curving line. The three stars are identified from west to east as A, B and C, with magnitudes of +4.6, +5.0 and +5.3. The B-C pair are separated by 2.8 arcseconds; A sits 7.4 arcseconds away from B.

In order to see the triple at its best we recommend using a magnification of 200x or higher. Once you've found the right star, centred up and focused, Beta Monocerotis is astonishing.

BINOCULAR TOUR

With Steve Tonkin

Sirius, Wezen and Furud point the way to February's best binocular targets



1. M41

10x 50 M41 is 4° south of Sirius (Alpha (α) Canis Majoris). This open cluster is bright enough for you to be able to see it with the naked eye in a transparent sky, and is large enough to be an obvious cluster of stars in 10x50 binoculars. From a dark-sky site, you should be able to resolve up to 10 brighter stars against the background glow of fainter stars if you use averted vision. ☐ **SEEN IT**

2. M46/47

10x 50 This pair of clusters, which lie 5° of Alpha (α) Monocerotis, offers contrasting examples of how open clusters can appear in small binoculars: the 1,600-lightyear distant M47 is large and loose but, although it appears to be a similar size, M46 is actually much larger, richer, and more compact. It is more than three times as distant at 5,500 lightyears and you may not be able to resolve any stars at all. ☐ **SEEN IT**

3. M93

15x 70 If you place Xi (ξ) Puppis at the southeast of the field of view, the wedge-shaped M93 should appear approximately in the centre of the field. M93 is a bright, rich cluster in which some 25-30 stars are visible in 15x70 binoculars, against a glowing backdrop of fainter stars. Unlike most open clusters, which are sparser at the periphery, M93 is unusual in that it is the centre of the cluster that is sparse. ☐ **SEEN IT**

4. UW Canis Majoris

10x 50 Look 2.7° northeast of Wezen (Beta (β) Canis Majoris) and you will see a pair of very blue stars. The brighter one is Tau (τ) Canis Majoris, but the more interesting star is the fainter (mag. +4.8) UW Canis Majoris, which lies less than 0.5° north of Tau. UW is a variety of eclipsing binary star, a blue supergiant whose brightness falls by half a magnitude every 4.39 days as it is eclipsed by its fainter companion. ☐ **SEEN IT**

5. The Omega Canis Majoris group

10x 50 Omega (ω) Canis Majoris lies 1.5° east of Wezen. Note that it is a brilliant white compared to the fainter yellowish star that is just to the south of it. The two are part of a pretty C-shaped string of stars of varying colour that extends from 26 CMa in the north, through 27 and Omega, to a 5th magnitude yellow star that is just over 1° south of Wezen. ☐ **SEEN IT**

6. Nagler 1

15x 70 A little less than 4° north of Furud (Zeta (ζ) Canis Majoris) is a little chevron of half a dozen 7th and 8th magnitude stars that extends for about 0.75°. This is the asterism Nagler 1; the east side is brighter than the west and, as well as some colour variation, you should notice that the member east of the apex of this celestial lance-corporal's stripe is actually a pair of fainter stars. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

Can you observe the green flash effect of Venus as it sets over the horizon?

▲ Venus setting over a tree-lined horizon showing atmospheric dispersion effects

Atmospheric dispersion spreads the light of Venus into a spectrum of colour

The green flash is an atmospheric phenomenon normally associated with the Sun. It's also often cited as an effect which is seen from the tropics when the Sun sets over a seaward horizon. In reality all of these statements are both correct and incorrect. While the green flash is best seen with the setting Sun over a seaward horizon in the tropics, it's by no means unique to either the Sun, sunset or the tropics. This month we're challenging you to see the effect with the bright planet Venus.

CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

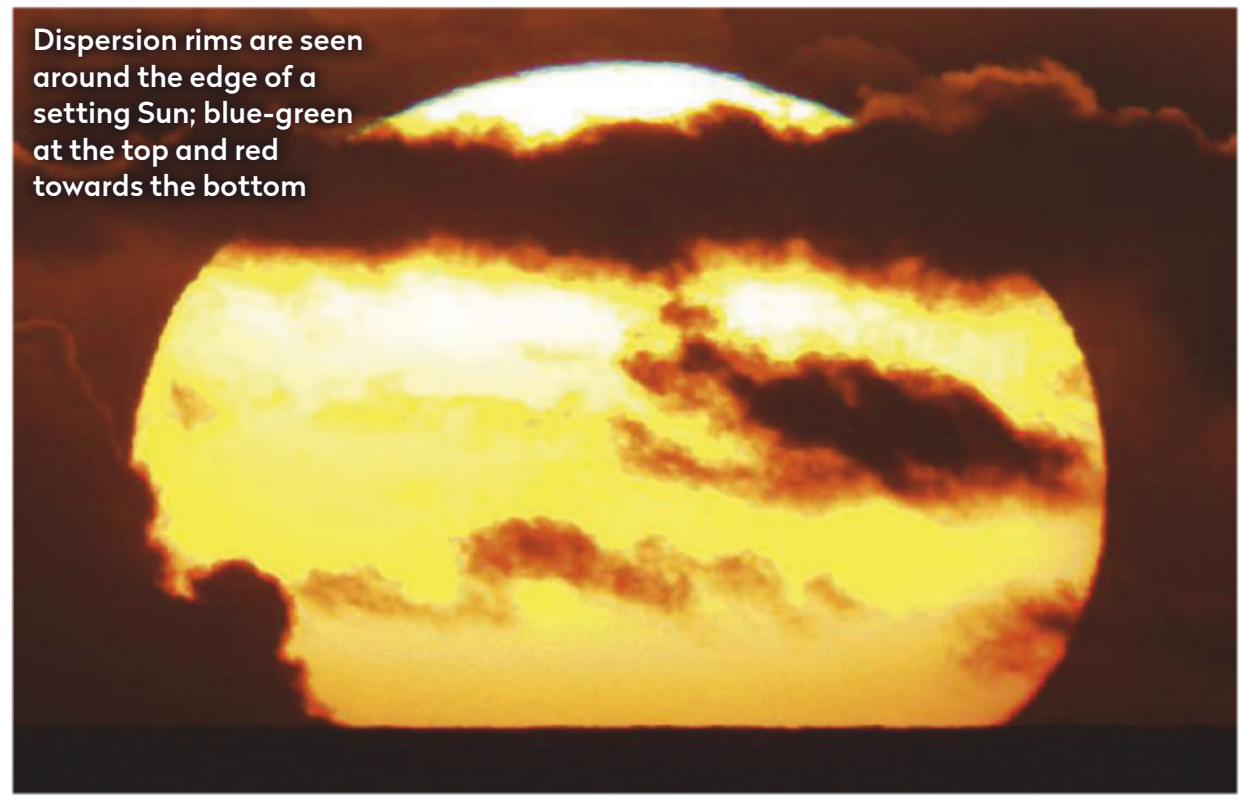
The phenomenon arises when light passes through Earth's atmosphere at low altitude. The atmosphere refracts light of different wavelengths in the same way that a prism does. Atmospheric dispersion as it is known, gets more pronounced as you approach the horizon because any incoming light has to pass through a thicker air mass here. Although the effect is small, it's enough to create the impression that a bright object – and this can be the Sun, Moon, stars or planets – has a red lower edge and blue upper edge.

Here, another atmospheric effect known as scattering kicks in. This causes the blue light to scatter and, unless your atmosphere is extremely clean, the blue edge is lost. This leaves the next colour in the spectrum to become dominant – namely green.

A true green flash occurs when an atmospheric inversion layer detaches the upper edge of a bright object so it hovers with the vivid colour of the dispersion edge above the object itself. This is most evident at sunset over a seaward horizon, but it can also occur for any bright object either rising or setting. It's also not limited to a sea horizon and can be seen to occur over a land horizon or even as the object sinks behind a low altitude cloud bank.

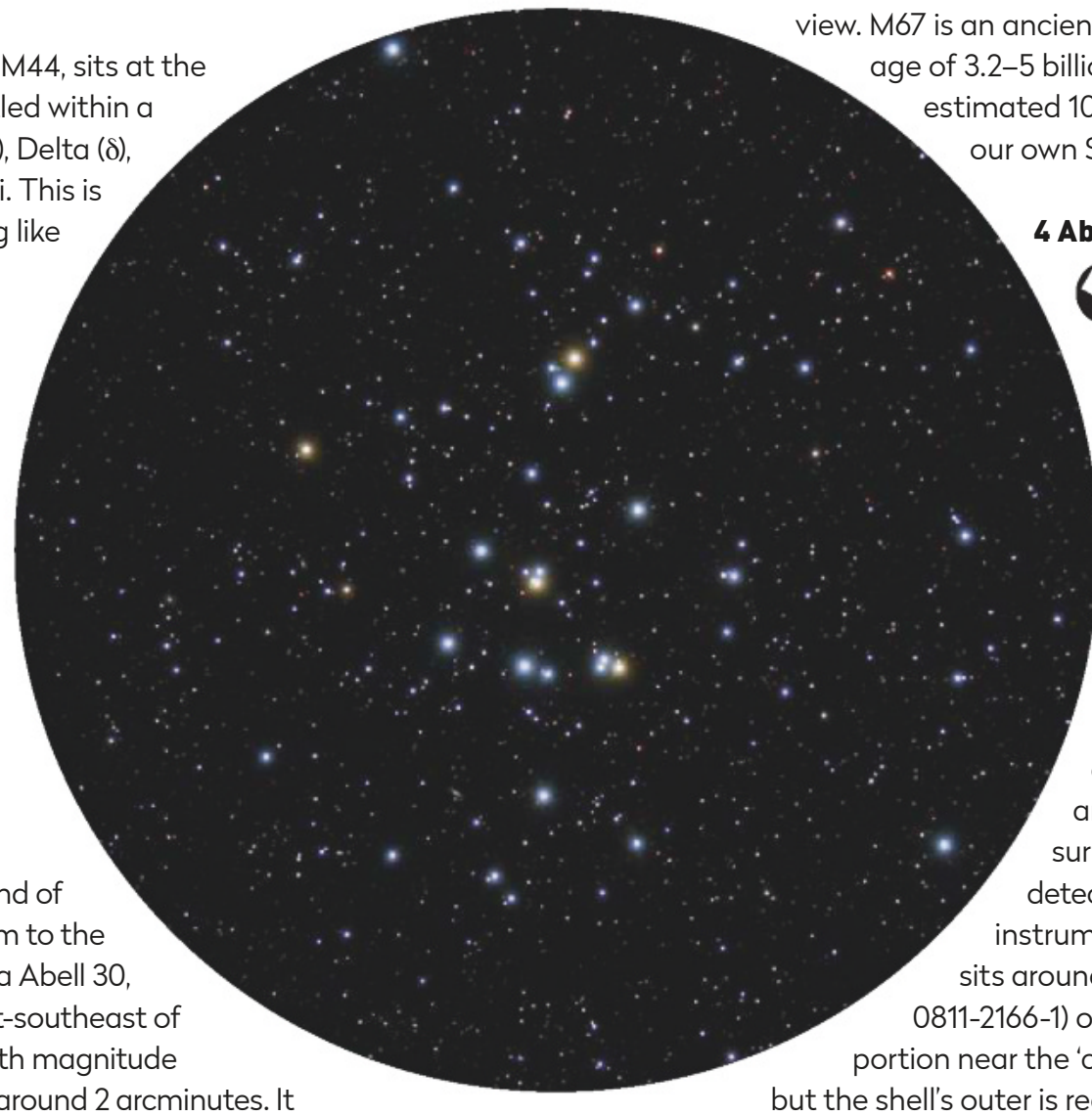
As Venus sets, it should be possible using a high magnification setup, to spot how atmospheric dispersion spreads its brilliant light into a spectrum of colour. Splitting the upper green portion off from the dispersed planet is perhaps a tall order with something so small, but taking a series of images in rapid succession, exposed to reveal the colour may bag you this rare phenomenon.

A DSLR or high frame-rate colour video camera looking through a long effective focal length telescope are ideal tools for this but be prepared for some real-time adjustment. As bright objects approach the horizon, the thicker layer of atmosphere they appear behind will rapidly attenuate their light, dimming their appearance. Good luck with your attempts and don't forget to send us your results.



DEEP-SKY TOUR

We take in the best celestial sights around Cancer's border with Hydra



▲ **Start easy: locate the Beehive Cluster, M44, in the heart of Cancer**

MANFRED WASSHUBER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

1 M44

The Beehive Cluster, M44, sits at the heart of Cancer, nestled within a 'box' formed by Gamma (γ), Delta (δ), Eta (ε) and Theta (θ) Cancri. This is not difficult to find, looking like a nebulous patch to the naked eye. It's one of the nearer open clusters to Earth at 577 lightyears. It's rich and has an apparent diameter of 95 arcminutes. In total, M44 contains around 1,000 stars. Some lovely colour contrasts can be seen through a small scope using a low-power eyepiece. ☐ **SEEN IT**

2 Abell 30

We swing from one end of the difficulty spectrum to the other with planetary nebula Abell 30, located 37 arcminutes east-southeast of Delta (δ) Cancri. This is a 13th magnitude planetary with a diameter around 2 arcminutes. It appears as a circular glow around its mag. +13.8 central star. It's large for a planetary nebula and this leads to low surface brightness. It's a great imaging target, but visually you'll need a 400mm or larger instrument. Even then, using an OIII filter, the nebula will only be 'seen' using averted vision. This is a rare object often described as a 'born again' planetary. It gets this title because after the central star turned into a white dwarf, it re-ignited. The mature planetary shell now surrounds the star together with a series of bright knots of glowing material formed after re-ignition. ☐ **SEEN IT**

3 M67

Next is the second of two Messier objects in Cancer, open cluster M67. It lies 1.7° west of mag. +4.3 Acubens (Alpha (α) Cancri). Appearing smaller and dimmer than M44, M67 has an integrated magnitude of +5.9 and appears condensed and rich through the eyepiece. A 150mm scope shows many stars brighter than 12th magnitude in a compact area 0.25° across. In total, M67 contains around 500 stars. Use a low power eyepiece for an overview, then increase magnification until you achieve your favourite view. M67 is an ancient object with an estimated age of 3.2–5 billion years. It contains an estimated 100 stars which are similar to our own Sun. ☐ **SEEN IT**

4 Abell 31

Planetary nebula, Abell 31 sits in southern Cancer, near the Hydra border. Locate it from mag. +3.1 star Zeta (ζ) Hydrae: 3° north and one third of a degree west of Zeta will bring you to Abell 31. It has an integrated magnitude of +12.2 but is even larger than Abell 30, with an apparent diameter of 16.8 arcminutes, giving it a low surface brightness. It may be detectable with 250mm aperture instruments under dark skies. It sits around its progenitor star (TYC 0811-2166-1) offset towards the west. The portion near the 'central' star is bright in OIII but the shell's outer is red, due to nebula material interacting with the interstellar medium. ☐ **SEEN IT**

5 NGC 2775

Our penultimate target is spiral galaxy NGC 2775. This is located closer to the southern border of Cancer, 3.7° east and 1.0° north of Zeta Cancri. This 11th magnitude galaxy is part of the Virgo Supercluster of galaxies. It's the brightest member of a smaller galaxy group within the Supercluster, known as the NGC 2775 group. In a 150mm scope it appears as a glow 2x1 arcminutes in size. It is visible as a central condensation with a halo in a 200mm instrument. The condensation represents the bright core of this galaxy, the outer halo being formed from a multitude of tight spiral arms. At 55.5 million lightyears, it has an apparent size of 4.3x3.3 arcminutes. A large scope shows it to have a size of around 3x2 arcminutes. ☐ **SEEN IT**

6 NGC 2713

We need to hop across the border from Cancer into Hydra for our final object. Look 3° south and 0.5° east of Zeta Hydrae. NGC 2713 appears as an elliptical east-west elongated glow through a 250mm scope. The glow surrounds what looks like a circular central core. It is estimated to be 169 million lightyears from Earth and is a barred spiral galaxy. It has a diameter of around 185,000 lightyears and is highly inclined to our line of sight. The mag. +12.8 galaxy NGC 2716 appears close to mag. +12.7 NGC 2713, lying 11 arcminutes north. ☐ **SEEN IT**

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

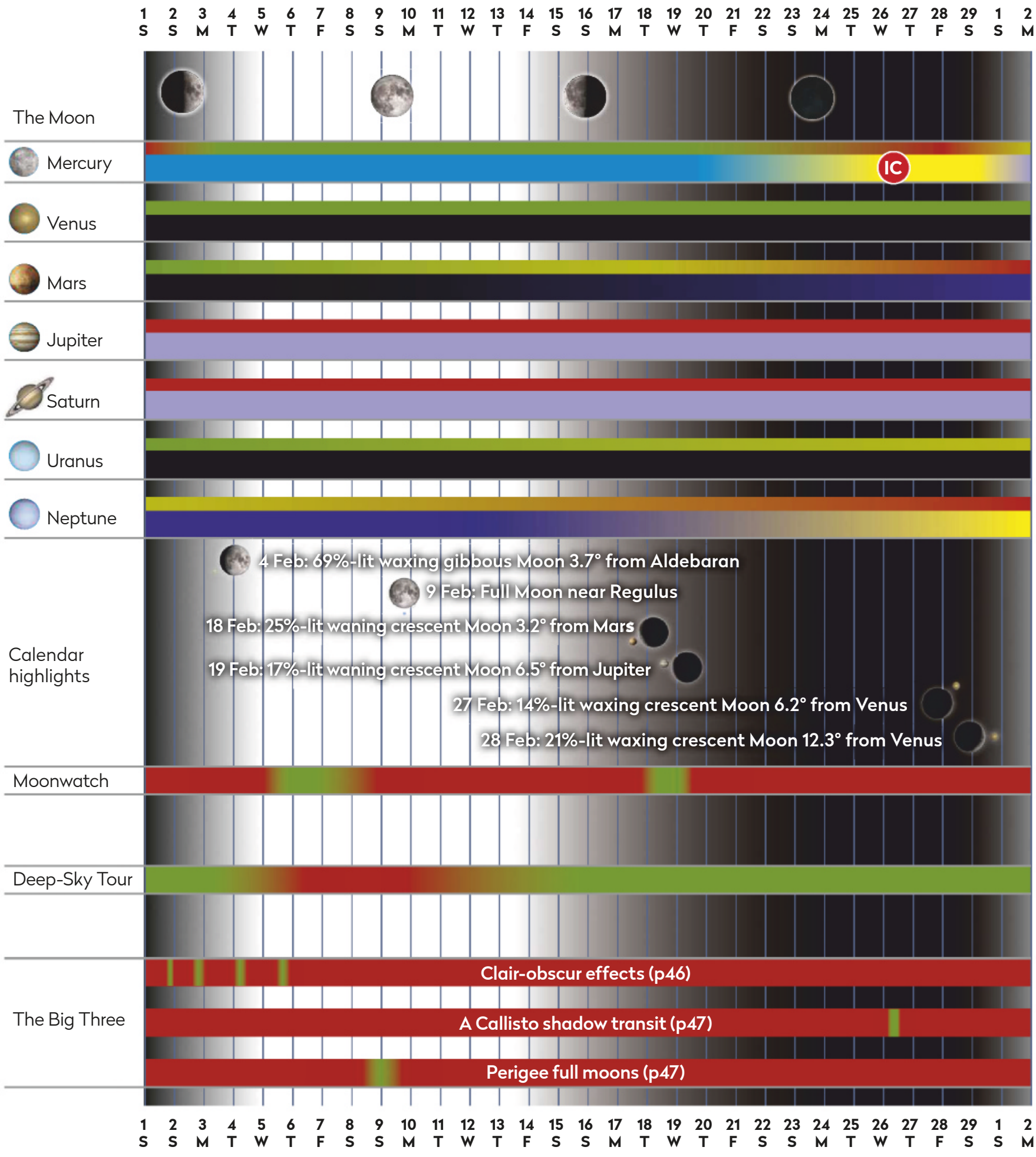
More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.

NGC 2565
NGC 2545
NGC 2599
NGC 2563
NGC 2595
Ecliptic
+20°
Asellus Borealis
γ
η
ξ
ζ
Tegmine
N
W
E
S
5°
2°
M44
1
NGC 2672
θ
δ
Asellus Australis
+20°
Abell 30
2
NGC 2749
+15°
Ecliptic
CANCER
o
NGC 2648
+15°
π
+10°
β
Altarf
Acubens
α
M67
3
κ
4
Abell 31
+10°
+5°
ε
δ
5
NGC 2775
ζ
NGC 2718
ρ
JC 2327
ω
σ
η
+5°
HYDRA
PGC 1250719
NGC 2716
NGC 2713
NGC 2765
6
0°
θ
0°

AT A GLANCE

How the Sky Guide events will appear in February



KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

Meteor radiant peak

Planets in conjunction

Full Moon

First quarter

Last quarter

New Moon

CHART BY PETE LAWRENCE

WE ARE THE DISCOVERERS... WHO GAZE UP INTO THE MOONLIGHT AND FOLLOW THE STARS OF THE DISTANT PAST

Imagine a place where we, the discoverers, roam through landscapes carved from pure imagination and lit by distant stars. We seek out the unexpected and the extraordinary.

With 26 official Dark Sky sites, the largest concentration of sites in the British Isles, the Isle of Man offers the perfect destination for a stargazing break.

Start your **#IOM**story now
Uncover more at visitisleofman.com/stargazing

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HOW MUCH OF THE NIGHT SKY CAN YOU SEE?

What are the effects of light pollution on stargazing and astro imaging? **Charlotte Daniels** and members of King's Lynn & District Astronomy Society find out

CHRIS GRIMMER/KLADAS

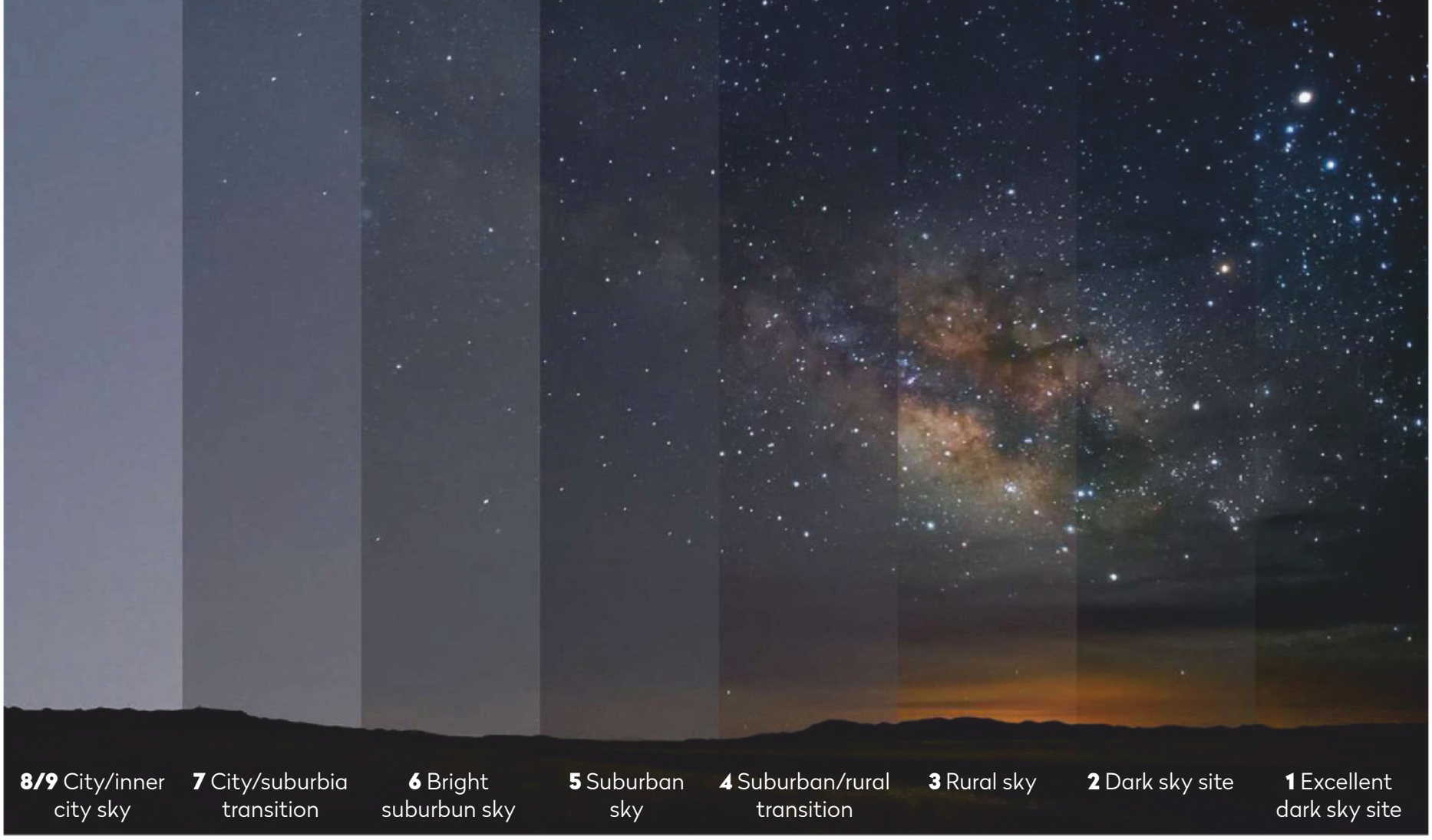
Bright skies: the three types of light pollution, sky glow, glare and light intrusion, are all evident in this photo of the night sky above Norwich

The night sky is full of amazing sights like star clusters, galaxies and planets which can be seen with the naked eye, and explored in more detail with binoculars and telescopes. But just how much you can see of these objects depends on the quality of your night sky and the impact of light pollution. This poses the question: what is visible in your area, and how does light pollution affect astronomy? In this article, we'll look at how artificial light affects stargazing and imaging across Norfolk, in order to show the kind of impact you can expect across the UK.

According to research by CPRE (Campaign to Protect Rural England) about 22% of England, 57% of Wales and 77% of Scotland has 'pristine' night skies free of light pollution. CPRE develops interactive maps of the impacts of light pollution on Britain's night skies and detailed maps of all English counties, National Parks and AONBs (Areas of outstanding natural beauty) based on satellite data. Its research into sky quality includes a Star Count survey.

"There are three types of light pollution," says Emma Marrington, dark skies campaigner at CPRE. "These are sky glow, glare and light intrusion." While sky glow is the pink-orange glow seen for miles around urban areas, glare is the uncomfortable brightness of a light source such as a security light bleeding into dark areas. Last, Emma explains that light intrusion is commonly caused by streetlights and domestic security lights. "Light pollution has no boundaries and blurs the distinction between urban and rural areas," she adds.

Light pollution has left many people who live in or near urban areas without a view of the Milky Way. This is where certified 'dark sky' sites help astronomers realise the hobby, regardless of where they live. Dark sky sites can be protected to some extent from light pollution. Astronomers often refer to the Bortle scale to qualify sky quality. This ranges from 1 (darkest sky) to 9 (extreme light pollution). While I live under Bortle 4 skies in East Anglia, the second darkest region in England, a dark sky reserve in the UK is as low as Bortle 2. ▸



▲ **The Bortle scale is split into nine levels for measuring the sky's brightness from a location**

► There are 12 International Dark-Sky Association (IDA) sites in the UK that possess the lowest Bortle skies. There are also over 100 Dark Sky Discovery sites that possess 'relative darkness' – skies that are darker than average and allow naked-eye views of Andromeda, the Milky Way and the Double Cluster.

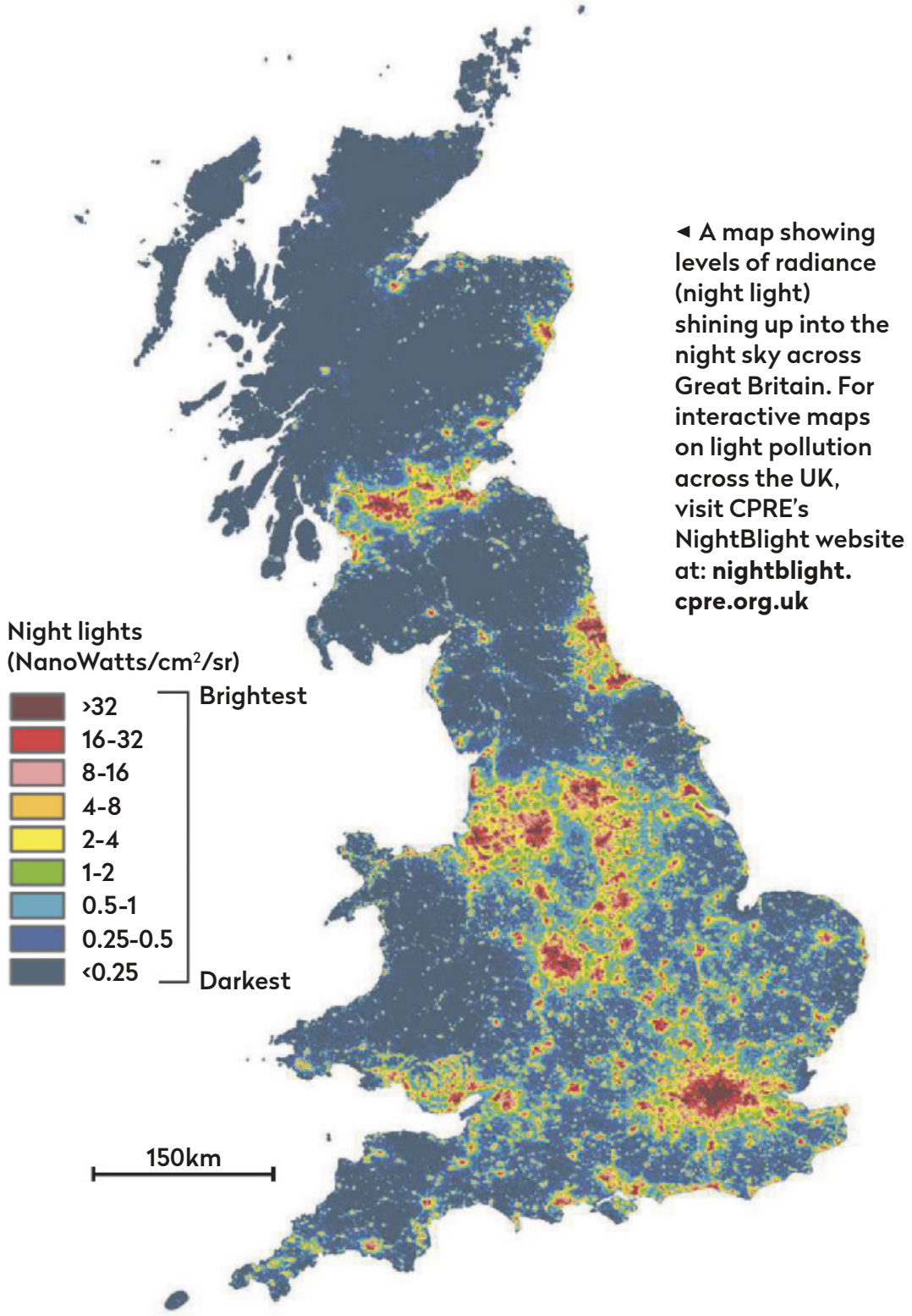
To certify the sky darkness at such a site, you use a light meter, which measures visual magnitude per square arcsecond. "This provides a quantitative measure of sky quality," says King's Lynn & District Astronomy Society (KLADAS) chairman John Craythorne, who has supported the dark-sky certification of two sites in East Anglia. He adds that at these sites you can expect to see distinct structure in the Milky Way, and more stars in constellations. "In Orion you can expect to see 30-35 stars," he advises.

Testing the skies

Visual observers arguably feel the effects of light-polluted skies more than astrophotographers. To assess the visual impact of artificial light we looked at Orion as well as those other popular winter sights of the Pleiades and the Double Cluster in Perseus. We tested whether we could see the Double Cluster with the naked eye, and how many of the nine stars within the Pleiades we could spot from a village, town and city.

CPRE's annual Star Count survey encourages people to identify the best and worst places for stargazing. Taking place nationwide every February, the initiative invites the public to report how many stars they can see in Orion. "In 2019, just 2% of stargazers reported seeing 'truly dark sky', meaning over 30 stars in Orion," says CPRE's Emma Marrington. "This number has halved since 2014." In 2019, 57 per cent saw fewer than 10 stars, she says.

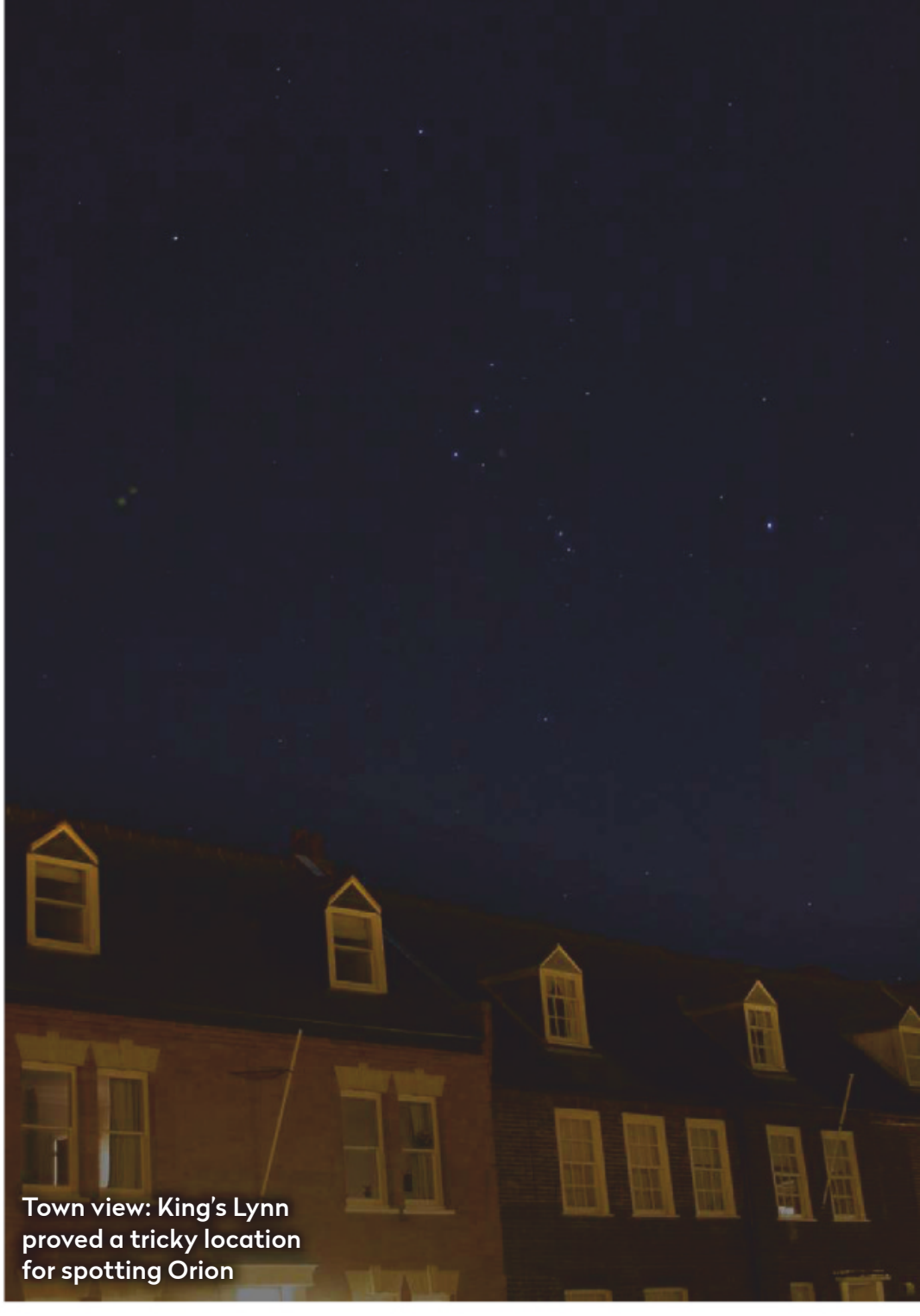
Our first star count of Orion was from the fenland village location of Totenhill. Immediate lighting in the region was minimal, and while security lights could be switched off, the lights in a neighbouring garden remained on. These were to the west and prevented us from observing anything close to the horizon in that



◄ **A map showing levels of radiance (night light) shining up into the night sky across Great Britain. For interactive maps on light pollution across the UK, visit CPRE's NightBlight website at: nightblight.cpre.org.uk**

WWW.SKYGLOWPROJECT.COM, EARTH OBSERVATION GROUP/NOAA NATIONAL GEOPHYSICAL DATA CENTER/ DATA PROCESSED BY LUC ON BEHALF OF CPRE, CHARLOTTE DANIELS/KLADAS X 2, CHRIS GRIMMER/KLADAS

Village view: Tottenhill proved a good location for making out 26 stars in Orion



Town view: King's Lynn proved a tricky location for spotting Orion

City view: it took 10 minutes to make out Orion while observing from Norwich

area. We counted 26 stars in Orion and seven of the main stars in the Pleiades, while we could see both Andromeda and the Double Cluster.

In our town location in King's Lynn, our eyes struggled to adapt. It was hard to avoid light flooding one's vision. From the town square, we could count five of the Seven Sisters and after several recounts we could see 16 stars in Orion, but from the town square the Double Cluster couldn't be made out.

Finally, from our city location in Norwich, the Pleiades initially appeared as a smudge in the field of view, but after a few minutes we counted five stars. Meanwhile, after looking at Orion for almost 10 minutes, we made out nine stars within the body of the constellation but were unable to see Andromeda or the Double Cluster.

Getting the picture

But how does light pollution affect photography of the night sky? If you're just getting into astrophotography and perhaps want to try it in your back garden first before seeking out a dark sky area, how will your sky quality affect the results? If you already know your way around an imaging setup, how does light pollution impact the kind of detail you can expect from your images? One of the key issues with light pollution is that it makes image processing your pictures difficult.

To give some representative examples of the effects of light pollution on imaging, members of KLADAS imaged during a new Moon from six locations, ranging from category 4 to 8 on the Bortle scale: a dark sky, rural, village, town, suburb and city site. At each ▸

▸ location, we looked at how easy it was to polar align. This is essential for accurate tracking and if you're manually aligning, a view of Polaris is required. If you're aligning a Go-To setup, you'll also need stars on either side of the Meridian line to align on.

Target Andromeda

We settled on the Andromeda Galaxy, M31, as our target (see images 1-6, right). With its dust lane definition and core detail, it has good attributes for a comparison across the sites. The images were captured using a refractor and DSLR setup without filters and had the same settings applied: ISO 800, 30 second sub-exposures, a two-hour integration time and 20 dark calibration frames. The same processing has been applied to all the images in Adobe Photoshop: we aligned the colour channels for each final image, upped the brightness, increased the contrast in the dust lanes, and applied tools to control noise (unwanted artefacts).

While the pictures are generally representative of the impact of light pollution on imaging, remember that the skies in your area will be affected differently by local lighting. Even in the darkest part of the UK, you'll still experience light pollution if a neighbour has security lights that aren't angled downwards. To stop this getting into a scope or your eyes, cover or screen the source with thick card. There is little that can be done for indirect light pollution. By the city image, it proved difficult to avoid direct light hitting the scope.

The dark sky image has clearly captured the most detail, while the rural and village images are similar. The town and suburban images begin to lose detail in the outer lanes, while the final city image struggles to get the contrast required for delicate structure.

Find out more

www.britastro.org/dark-skies
Visit the Commission for Dark Skies to discover work that is underway to control light pollution.

www.cpre.org.uk/dark-skies
Find details of how to take part in the CPRE's Star Count and how to find your nearest dark skies.

www.darksky.org
Discover details of the premier dark sky locations in the UK and across the globe.

www.darkskydiscovery.org.uk
Where to find dark sky sites suitable for stargazing across the UK.

JOHN CRAYTHORNE, GARY HILL, NEIL WILSON, TONY MOSS, ALAN GOSLING, CHRIS GRIMMER

Galaxy quest

Comparing images of the Andromeda Galaxy from different locations

1. DARK SKY DISCOVERY SITE – RSPB TITCHWELL MARSH, NORTH NORFOLK
Bortle category: 4
Light pollution: Some distant skyglow.
Polar alignment: Difficult to find Polaris through the polarscope because so many of the stars appear bright. An aircraft passes overhead close to the North Star, which helps confirm the correct alignment.
Star alignment: Lots of options to select from and settle on Vega and Alioth.
Observed: The Andromeda Galaxy looks bright to the naked eye from this site, as does the Double Cluster. Open clusters M35, M36 and M37 are visible.
Not observed: Cannot see the Triangulum Galaxy, M33.
John Craythorne, Chairman, KLADAS

2. RURAL SITE – MAGDALEN, NORFOLK
Bortle category: 4
Light pollution: The few LED streetlights don't cause problems when observing, and nearby security lights point away from the imaging setup. There is some skyglow from King's Lynn but the main problem is from a stadium 8km away.
Polar alignment: Quickly done, with Polaris easy to make out.
Star alignment: Other than some stars that are too low, there is a good choice.
Observed: Good lane structure in the Milky Way.
Not observed: Stadium lights influence what I can see in the lower northern sky.
Gary Hill, KLADAS member

3. VILLAGE – TERRINGTON ST CLEMENT, NORFOLK
Bortle category: 4
Light pollution: No streetlights but a neighbour has left outside lights on, illuminating the garden. Infrared (IR) lights on nearby security cameras covered over before imaging.
Polar aligning: Good, with a clear view to the north above the roof line.
Star alignment: View to the east is obstructed, which limits stars.
Observed: After 20 minutes, I can see Andromeda and the Double Cluster.
Not observed: For the Orion Star Count, I could only make out about 20 with the naked eye from this village location.
Neil Wilson, KLADAS member

Charlotte Daniels (centre) is a journalist and member of King's Lynn and District Astronomical Society. KLADAS members (from left) **Gary Hill**, **John Craythorne**, **Tony Moss**, **Alan Gosling**, **Neil Wilson** and **Chris Grimmer** took the images of M31.

4. TOWN – DOWNHAM MARKET, CAMBRIDGESHIRE
Bortle category: 5
Light pollution: Sky glow from Downham Market and issues with local house lights.
Polar aligning: No issues here. Polaris is one of the brightest stars to be seen.
Star alignment: Horizon to the east is limited, which affects alignment and available objects.
Observed: Both Andromeda and the Double Cluster are seen; they're high in the sky and clear of light pollution.
Not observed: It's a struggle to see either object when they're not overhead, as sky glow masks them.
Tony Moss, KLADAS member

5. SUBURB – WEST LYNN, NORFOLK
Bortle category: 6
Light pollution: There's orange sky glow to the east and one LED streetlight to the west affects southern and easterly views.
Polar aligning: Using Celestron StarSense for polar alignment makes the process easier in light pollution.
Star alignment: StarSense provides options to align, despite limited visibility.
Observed: The Milky Way or naked-eye objects cannot be seen from here.
Not observed: While unable to observe anything with the naked eye, objects such as the Double Cluster are clear in a scope.
Alan Gosling, Secretary, KLADAS

6. CITY – NORWICH, NORFOLK
Bortle category: 8
Light pollution: There's the three types of light pollution from all sides of my setup.
Polar aligning: Polaris is one of the only stars that is bright enough to see from here.
Star alignment: Limited horizons mean I have next to no alignment stars available, particularly ones that are far apart.
Observed: Other than the Moon, only the main stars of key constellations.
Not observed: Everything else. No choice but to travel to my local dark sky site.
Chris Grimmer, KLADAS member

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A beginner's guide to TELESCOPE MOUNTS

Astronomer **Will Gater** explores one of the most important pieces of a telescope – a piece that's all too often overlooked: the mount

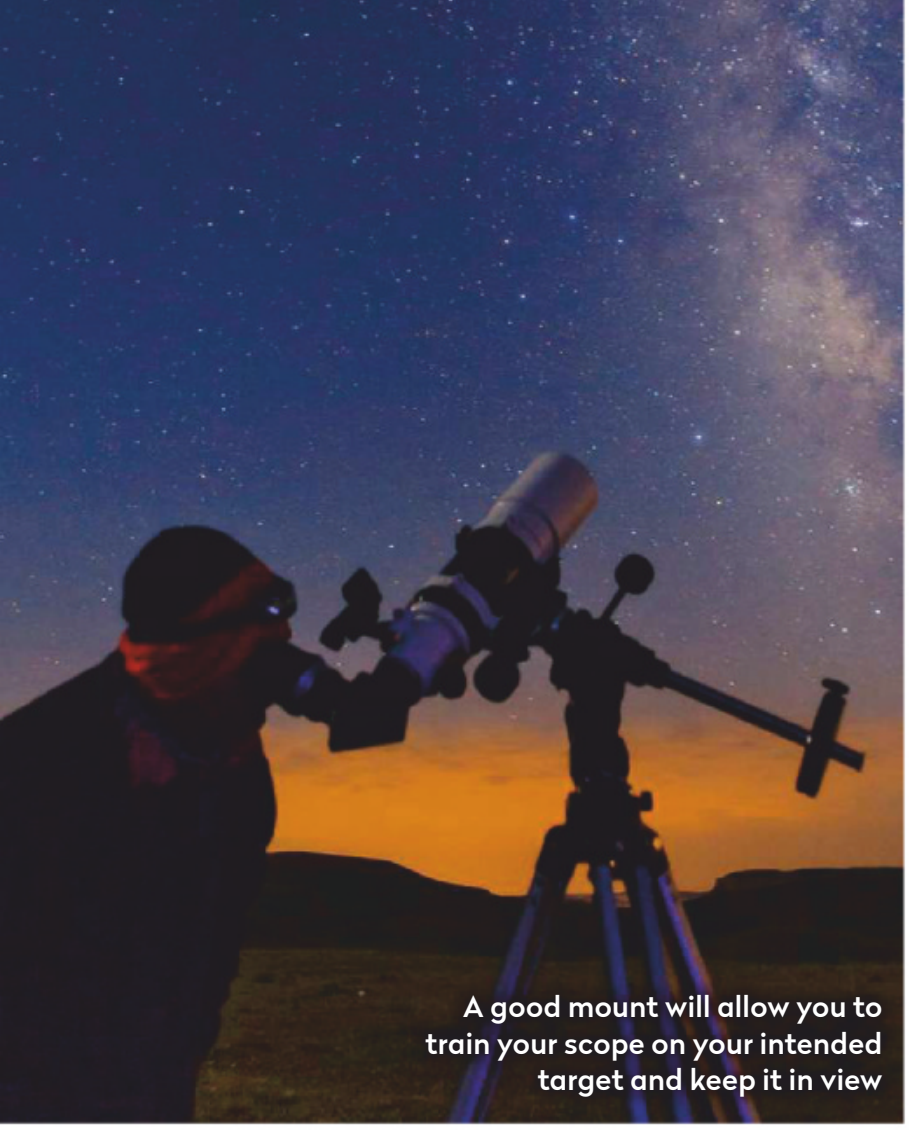
A good telescope mount is the bedrock upon which any decent observing or imaging setup is built. In this guide, we're going to explore everything you need to know about mounts, starting with the basics – what they are, what they do and why you should think carefully about which type you choose when buying your first scope.

At its most basic, a mount has to do two things: one, hold your telescope securely; and two, allow you to move the telescope so that it can be pointed precisely at the objects in the night sky you want to observe.

Most mounts achieve the first requirement (holding your telescope securely) using a combination of two elements: a tripod, with legs made of either wood or metal, and what's known as the 'mount head'. The mount head is typically made of metal and is where the two axes of the mount and any fine-tuning controls are located. Some types of ▸

Telescopes often get most attention but they wouldn't be of much use without a decent mount

MATTEO COLOMBO/ISTOCK/GETTY IMAGES, WWW.SECRETSTUDIO.NET



A good mount will allow you to train your scope on your intended target and keep it in view

► mount are even simpler than this, while others use a metal 'pier' instead of a tripod.

The key thing is that whatever type of mount you decide to use, it needs to be rock solid. Any play or looseness in it will be a source of immense frustration when you're observing. This is because any vibration in the mount will be transmitted to the optics resting on top of it, where the effect will appear magnified, ruining your view of the stars until the shaking has subsided. Even the tiniest tremor from a wobbly tripod leg can translate to the view of a celestial object moving dramatically in the eyepiece.

Moving on its axes

The second function a mount has to perform is enabling you to point your telescope at the objects you want to observe.

Most basic mounts allow you to move a telescope slowly and precisely in two axes using a set of controls; these generally take the form of large knobs on the mount head. Sometimes there are flexible metal rods that hold these knobs away from the mount to make them easier to use in the dark. Other mounts have electric motors that are controlled by the buttons on a handset, but the principle is the same.

The crucial thing about any mount controls, whether they're electric or manual, is that they provide a smooth, regulated motion so that small, precise adjustments can be made during your observations.

If you look at a selection of basic telescope mounts you'll notice they broadly fall into two categories: alt-azimuth mounts ('altaz', for short) and equatorial mounts.

The head of an altaz mount has two axes of motion; one that moves up and down from horizontal (0°) to vertical (90°), referred to as the altitude; and another that runs in a full 360° circle parallel to the horizon, known as the azimuth. If you want to point an altaz mount to a celestial object, you adjust the controls to rotate and raise the scope in the same way you would if you were turning your head to look at something. Altaz mounts are used to great effect on Dobsonian telescopes – on these instruments, the mount takes the form of a cradle (which allows the telescope to pivot in altitude) that sits upon a flat, rotating base.

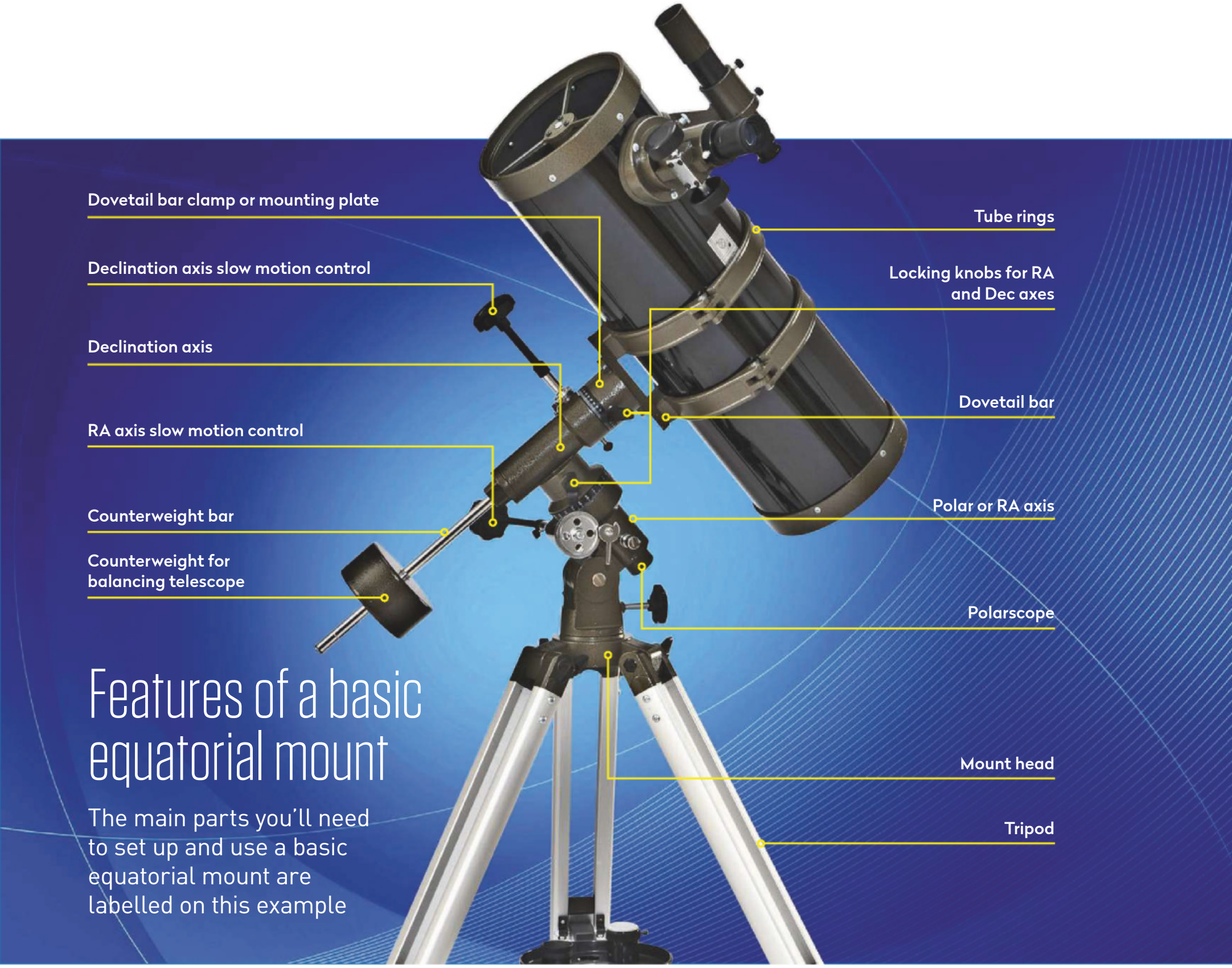
Equatorial mounts are a little more complex and probably the most popular mount type used by astronomers and astrophotographers. To understand why they are so popular, we need to briefly explore the basics of how the night sky is charted.

Astronomers imagine that the stars are mapped onto the inside surface an imaginary globe called the 'celestial sphere', which we sit at the centre of. This sphere has an axis of rotation that runs from a point called the 'North Celestial Pole', down through Earth's axis and out the other side to a 'South Celestial Pole'. Because Earth is rotating, the objects we see on the celestial sphere move across our sky; we see this as the stars, planets and galaxies drifting from east to west during an evening. If you want to find an object on the celestial sphere you need its coordinates. These are known as the right ascension (RA) and declination (dec.) and are similar to longitude and latitude on Earth's surface.

► Dobsonian telescopes use a simple altaz mount design

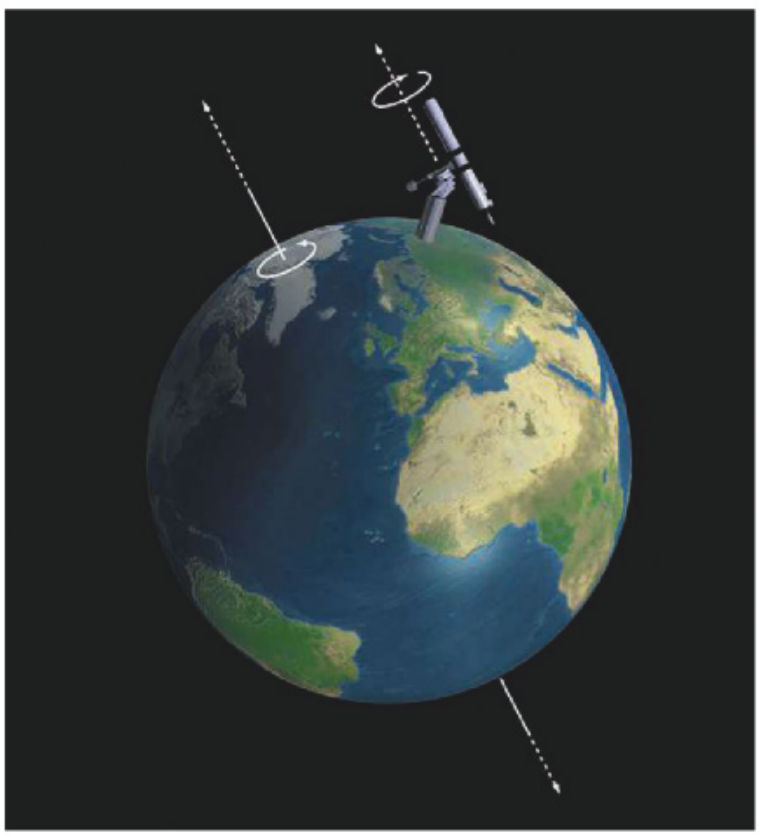
▼ Altaz mounts (left) move through horizontal and vertical planes while equatorial mounts (right) track objects by moving through an arc

NATIONAL GEOGRAPHIC IMAGE COLLECTION/ALAMY STOCK PHOTO, WWW.SECRETSTUDIO.NET X 4, PAUL WOOTTON



Features of a basic equatorial mount

The main parts you'll need to set up and use a basic equatorial mount are labelled on this example



► **A polarscope will align your telescope with Earth's rotational axis**

An equatorial mount works by having one axis – known as the polar or RA axis – aligned with Earth's rotational axis, and therefore the rotation of the celestial sphere. You can achieve this by using a small instrument called a polarscope, which sits inside the mount along the polar axis. Inside the polarscope is a reticule (a viewfinder with markings to help you line up your telescope) that, with the help of the star Polaris, can be pointed precisely at the North Celestial Pole. Once 'polar aligned' in this way, the other axis of an equatorial mount can then be moved along lines of declination on the celestial sphere. The controls on an equatorial mount essentially work in the same way as those on an altaz mount, except because an equatorial mount head is polar aligned, the scope moves within the RA and declination coordinate system on the celestial sphere.

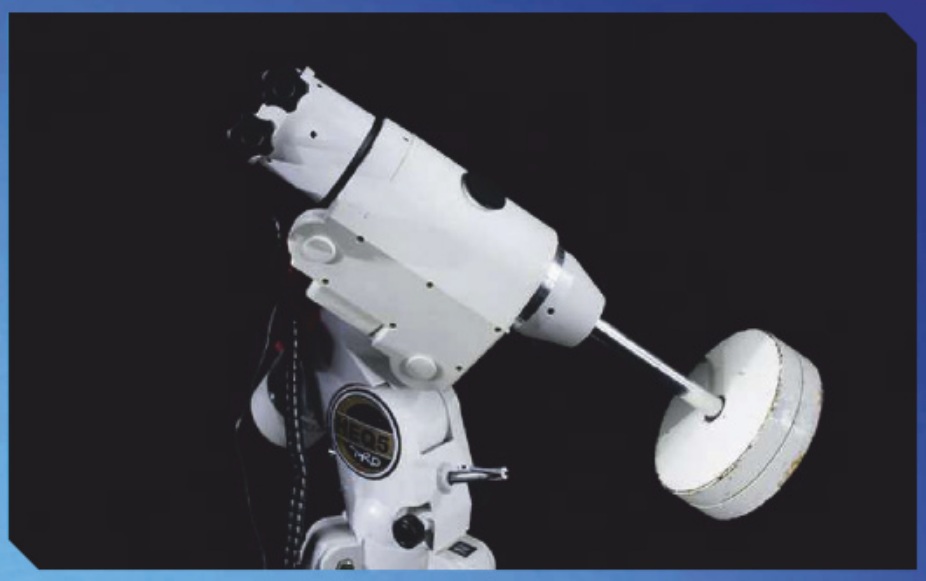
Track your target

What makes equatorial mounts so attractive to astronomers and astrophotographers is that all they need do to track a celestial object on the sky (which is to say, keep it in the field of view of an eyepiece for a long time) is rotate the polar axis at the same rate as Earth rotates. This can be achieved either by manually adjusting the controls or, more commonly, with a small electric motor.

Many basic equatorial mounts make use of this, creating what's known as a driven or motorised ►

How to polar align an equatorial mount – the basics

Accurate alignment is a vital part of setting up an equatorial telescope

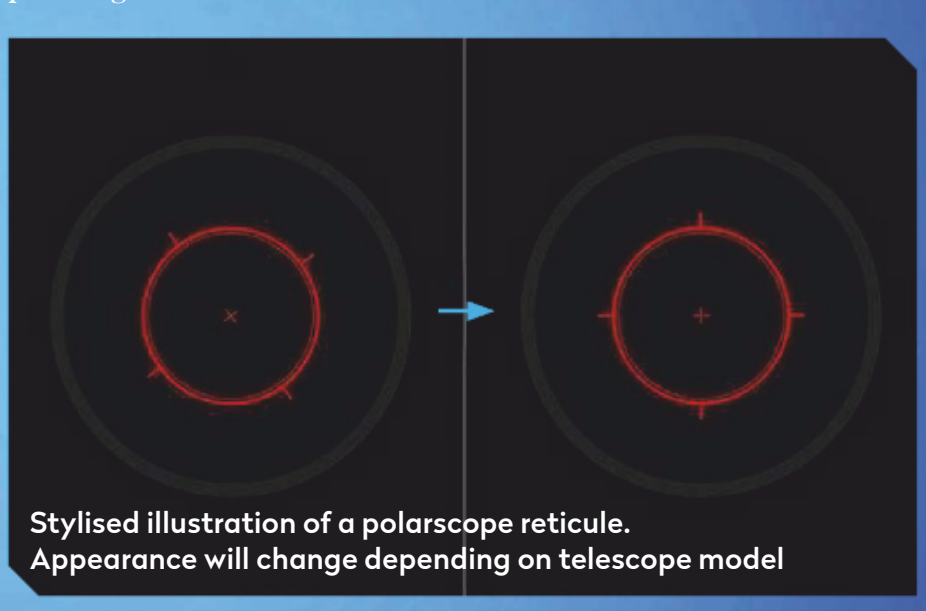


Orientate the tripod and mount head

First, set up the tripod; one of its legs may be marked to indicate that it should be pointing north. Attach the mount head securely to the tripod, making sure to place it in the starting configuration advised by the manufacturer – for example, with the polar axis pointing north.

Set the polar axis

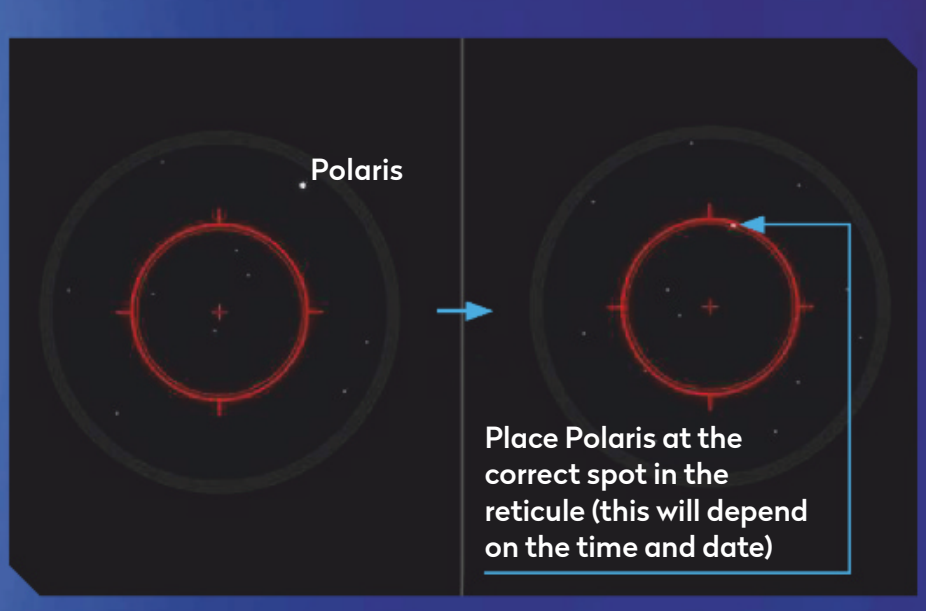
Next, check that the altitude of the polar axis is set to your latitude – that is, that the axis (the blue arrow and line above) is pointing towards the North Celestial Pole. If it's not, this can usually be done by carefully tweaking the altitude adjustment knob located at the base of the mount head.



Stylised illustration of a polarscope reticule. Appearance will change depending on telescope model

Orientate the polarscope's reticule

The polarscope reticule now has to be set to its starting orientation, if it's not already. Your mount's manual will tell you what this is and how to do it. On some mounts, for example, it's done by carefully rotating the polar axis until the reticule points in a certain direction.



Place Polaris in the reticule

There are some more convoluted ways to do this final step, but probably the easiest method for beginners is to download a polarscope smartphone app. It'll tell you how much you need to rotate the polar axis, if at all, and exactly where to place Polaris in the reticule.

▸ equatorial mount. Tracking celestial objects with an altaz mount is a much more complicated affair, requiring both axes to be motorised and, typically, controlled by a computer handset.

It is possible to convert certain altaz mounts into equatorial mounts, but doing so requires a device called an equatorial wedge. Some telescopes are sold with integrated altaz mounts, which hold the telescope tube via one or two arms. When an equatorial wedge is inserted underneath the base of such a mount, it allows the altaz head to be tilted and aligned towards the North Celestial Pole, which effectively turns the azimuth axis into a polar axis and the altitude axis into a declination axis.

Make sure they match

If you're buying a telescope and mount separately, you'll need to think about how the two fit together. Most telescopes are connected to a mount via a set of fabric-lined metal rings that hold the telescope tube, called 'tube rings'. The rings are usually connected to a metal bar – known as a 'dovetail bar' due to the shape of its profile – via a set of bolts. This dovetail bar then sits in a channel with a matching

Will Gater is an astronomy journalist and science presenter based in the UK

▲ The addition of a wedge can turn an altaz mount into an equatorial one

profile on a mounting plate – sometimes referred to as a saddle or clamp – at the top of the mount head. Here, one or two bolts, typically with large handles, are used to secure the bar tightly into the channel, so the telescope cannot move or slip.

The profiles of mounting plates and dovetail bars are not universal, however, so check which type your telescope has.

It's also worth noting that sometimes control knobs, locking bolts and the bolts used to secure a dovetail bar to the mount head can all look and feel similar in the dark. Make sure you're absolutely familiar with which is which before you adjust or loosen anything. The last thing you want is your telescope violently swinging around or, worse, crashing to the ground.

Should you go for Go-To tech?

There's one other feature of astronomical mounts that any beginner is bound to encounter. This is 'Go-To' technology. It can be found on all types of mounts and even on relatively small telescope setups. Go-To mounts are fully motorised and controlled with a small, computerised handset.

Typically, Go-To mounts need to be calibrated before use and the calibration procedure often varies between brands and models, so it's worth checking out exactly what routine is required before you invest in one. Generally, though, it starts with setting up the mount in a certain orientation – for example, with the polar axis pointing north. Once it's powered up, the mount will usually ask for the date and time, then turn the telescope to point at several stars, each of which you'll have to centre in the eyepiece. Once that's been done, the mount will 'know' where it's pointing and can then be directed towards any of the celestial objects in the handset's database, which can number in their thousands.

With so much to take in, choosing the right mount can involve a fair bit of thought. If you're overwhelmed, we recommend speaking to experienced astronomers and reputable suppliers about your possible options. One thing you can be sure of though is that any effort you put in at this stage will be worth it. A bit of research now should ensure you get off to a solid start when you take your first steps into the world of astronomy.

▼ Go-To scopes allow you to control the mount and search the sky with a computerised handset

Choosing a beginner's mount

A few key questions to think about before buying your first telescope mount

How portable does it need to be – will you need to carry the mount?

Consider where you'll be using the mount most. If you're going to be travelling to a dark-sky site you may find that lugging around a large equatorial mount will become tiresome. A smaller, portable tracking mount or a lightweight altaz setup could be more in line with your requirements, especially if you aren't up to lifting heavy loads.

What sort of observing will you be doing?

Your choice of night-sky target may have a bearing on what type of mount you opt for. If you intend to do solely visual observing of faint objects, it's probably better to opt for a simpler, less expensive, mount design and spend any money you save on bigger or better optics. For example, you may go for a non-motorised altaz mount or Dobsonian telescope (with its simple, integrated mount) rather than a higher-end Go-To equatorial mount.

Have you future-proofed yourself?

Consider what you might want to try in the future. For example, can the mount be easily adapted for astrophotography? And if you upgrade your telescope, would the mount be capable of carrying the new one safely?

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The fundamentals of astronomy for beginners

EXPLAINER

ASTRONOMERS YOU SHOULD KNOW
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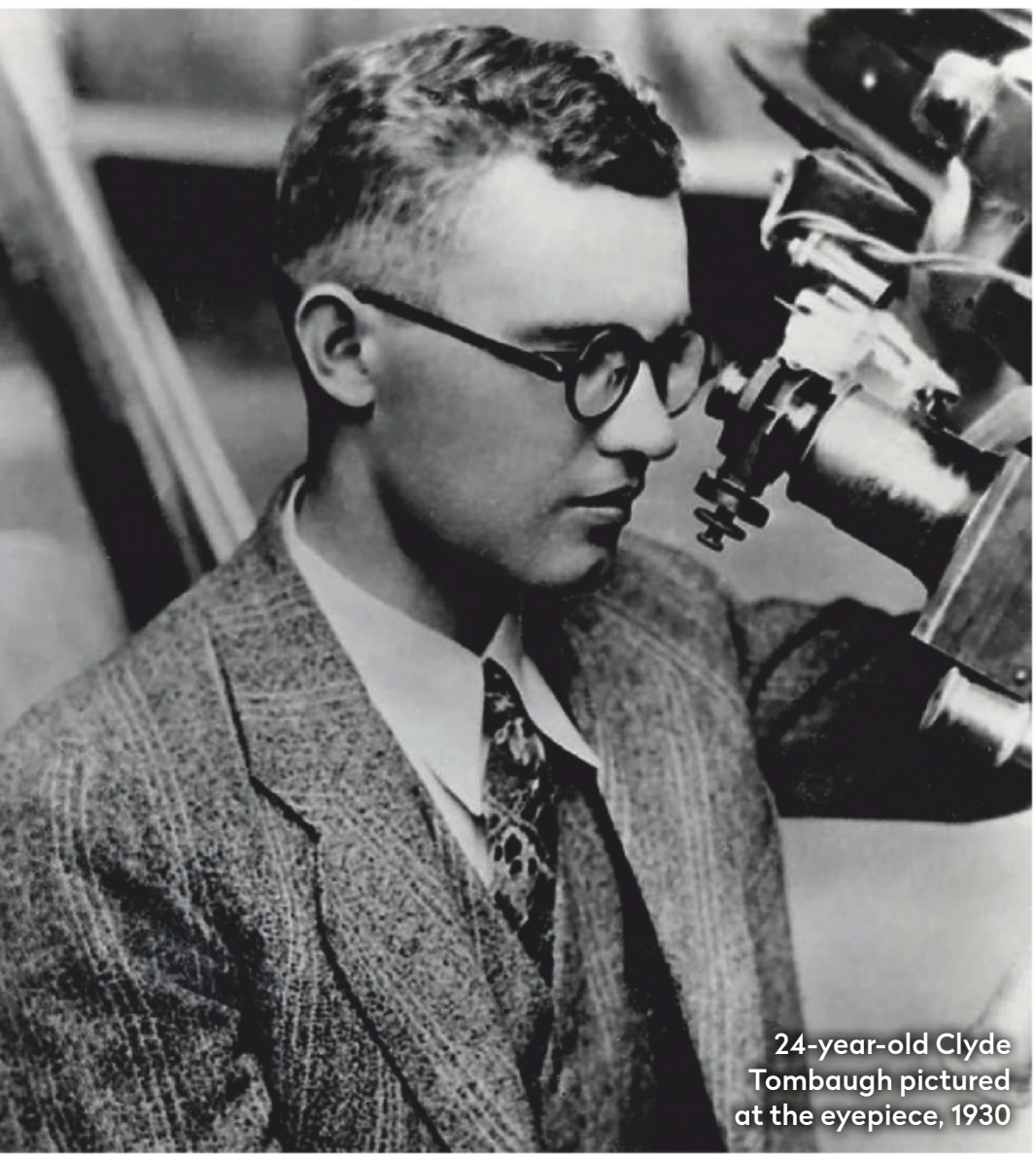
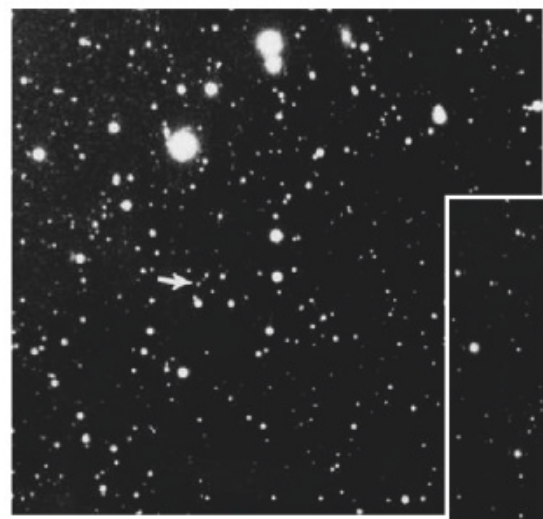
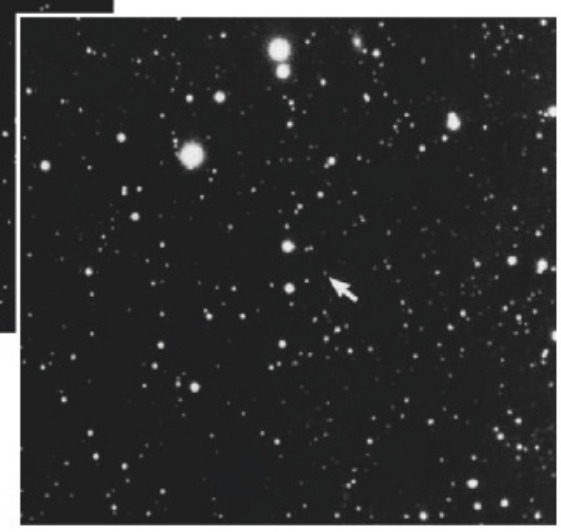
Clyde Tombaugh

The American amateur astronomer discovered Pluto 90 years ago this month



24-year-old Clyde Tombaugh pictured at the eyepiece, 1930





◄ ▼ The two plates that Tombaugh 'blinked' back and forth to reveal Pluto

▼ The 13-inch wide-field astrograph built to search for 'Planet X'

This month marks the 90th anniversary of the discovery of Pluto by Clyde Tombaugh at Lowell Observatory in Flagstaff, Arizona. Following the find on 18 February 1930, Tombaugh earned degrees in astronomy from the University of Kansas and taught astronomy at New Mexico State University. But at the time of Pluto's discovery, he was a young amateur astronomer who lacked any formal astronomy training.

Tombaugh was born in 1906 to a farming family that moved to Kansas in 1922, when he was 16. A hailstorm one year devastated the farm's crops, causing a financial burden that prevented his family from sending him to college. But that didn't deter him from pursuing astronomy on his own. When he was 20 he

Dr Danielle Adams is a cultural astronomer and deputy director at Lowell Observatory in Flagstaff, Arizona. For more on the story of Pluto, visit **https://lowell.edu**

built his first telescope and over the next two years he learnt how to grind and test optics, then designed and built two more. He used the last of these, a 9-inch Newtonian reflector built in 1928, to make detailed drawings of Mars and Jupiter, which he sent to several observatories for feedback. The drawings impressed the Lowell Observatory director at the time, Vesto Slipher, so much that he hired Tombaugh as an assistant and groundskeeper and brought him to Flagstaff in January 1929.

Meanwhile, Lowell Observatory had been preparing to begin a third search for 'Planet X', a body that Percival Lowell had theorised must exist beyond the orbit of Neptune. Percival had died in 1916 and his brother, A Lawrence Lowell, then president of Harvard University, funded the construction in 1927 of a 13-inch wide-field astrograph and its dome. The new astrograph saw first light in February 1929 and the third search for Planet X began with it on 6 April 1929.

Hunting Planet X

The search for Planet X was tedious, but it was a welcome departure from Tombaugh's groundskeeping role, which included stoking stoves with coal and shovelling snow off the various telescope domes. Each exposure took on average one hour, during which Tombaugh continuously kept the instrument centred on a guide star in order to ensure that star images were not distorted. Each evening yielded a handful of photographs, which Tombaugh developed during the day. Then the most challenging work began, as the star fields were examined for points that moved over time.

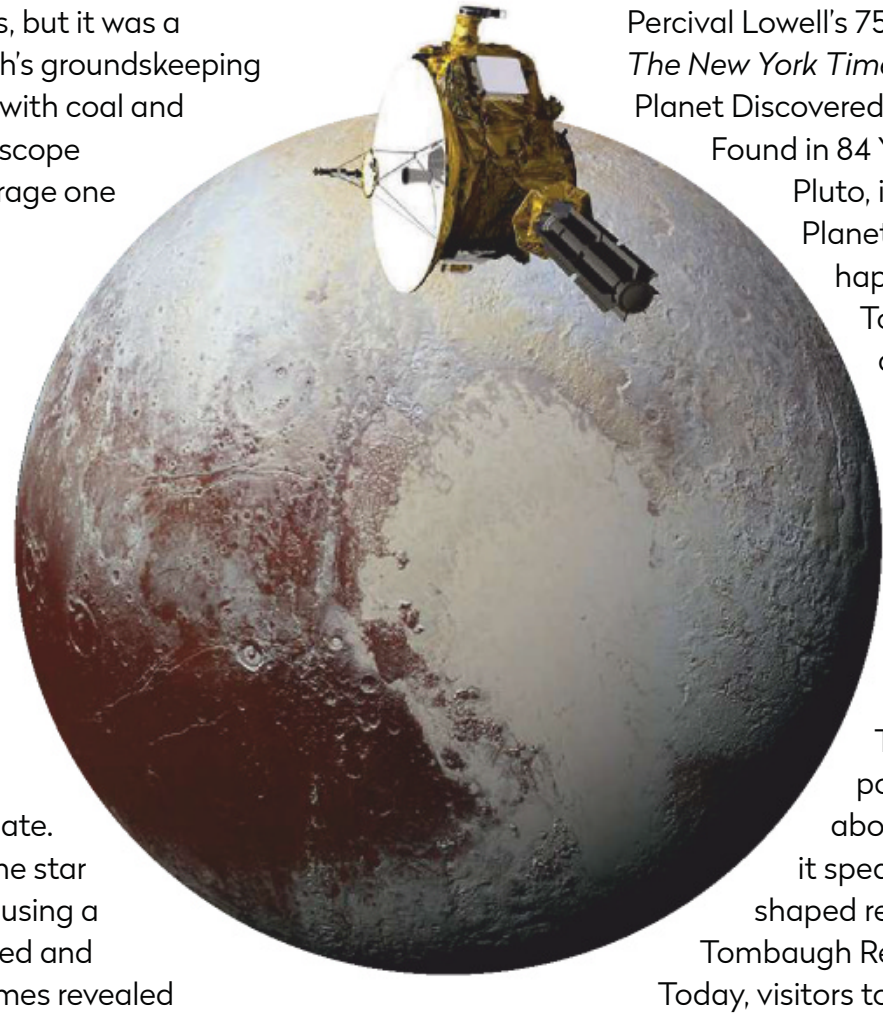
The photographs taken with the 13-inch astrograph had a wide field of 12x15°, capturing on average 300,000 stars on each 14x17-inch plate. Tombaugh would compare the same star fields, captured several days apart, using a Zeiss blink comparator. When aligned and blinked back and forth, the two frames revealed non-stellar objects as points of light that moved against the comparatively stationary star field.

After 10 months of monotonous searching, on 18 February 1930 Tombaugh found a point of light that was moving at the right speed to be a trans-Neptunian planet. The two plates he was comparing had been taken on 23 and 29 January, so he anxiously awaited clear, dark skies to confirm the current position of the suspected planet. Over the next several weeks, Tombaugh and his colleagues took new photographs and examined old plates to confirm the discovery. The new planet was announced to the world on 13 March 1930, the day that would have been Percival Lowell's 75th birthday. On the following day, *The New York Times* headline proclaimed: "Ninth Planet Discovered on Edge of Solar System: First Found in 84 Years."

Pluto, it turned out, was too small to be Planet X, so its discovery was yet another happy accident of scientific inquiry. Tombaugh continued to search for additional planets beyond Neptune at Lowell until 1945, discovering new asteroids, variable stars and galaxies along the way.

Distant Pluto remained largely an enigma until 2015, when the New Horizons mission captured detailed images of the dwarf planet for the first time. Tombaugh having died in 1997, a portion of his ashes were carried aboard the New Horizons spacecraft as it sped past Pluto, and the large heart-shaped region of Pluto was named Tombaugh Regio in his honour.

Today, visitors to Lowell Observatory, 'the Home of Pluto', can retrace Tombaugh's steps from the Slipher Building, which houses the blink comparator, to the Pluto Dome and the 13-inch astrograph, both of which were fully restored in 2018. Tombaugh will also be remembered on the 90th anniversary of Pluto's discovery at the I Heart Pluto Festival on 15 February 2020 at Lowell Observatory (**iheartpluto.org**).



▼ Our best view of enigmatic Pluto to date, taken by NASA's New Horizons probe

ARIZONA MEMORY PRIOJECT X 3, GALAXY PICTURE LIBRARY/ALAMY STOCK PHOTO NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE

Venetia Burney

The new planet's name was suggested by a young English girl

Not only was Pluto discovered by a young amateur astronomer, credit for its name goes to Venetia Burney, an 11-year-old girl from Oxford in the UK.

After hearing news of the new discovery, she became the first to suggest the name 'Pluto', after the Roman god of the underworld. Her grandfather shared the name with an Oxford astronomer, who sent a brief telegram to Lowell Observatory on 16 March: "Naming new planet please consider Pluto, suggested by small girl, Vebtia Nurney [sic], for dark gloomy planet."

Pluto was announced as the name for the new planet on 1 May 1930. The first two letters of 'Pluto' evoked the initials of Percival Lowell and so they were combined to form ♇ Pluto's astronomical symbol.

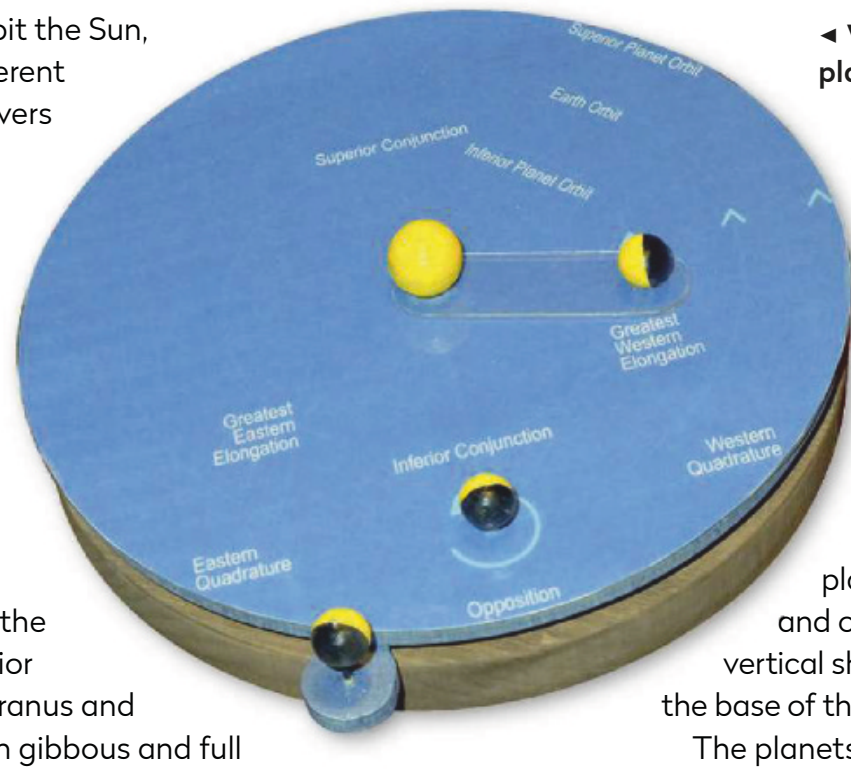
DIY ASTRONOMY

FAMILY FRIENDLY PROJECT

Make a planetary phase model

Construct a home-built model to learn about the phases of the planets

As the planets orbit the Sun, they exhibit different phases to observers on Earth. The inferior planets (Mercury and Venus) exhibit a similar range of phases to the Moon – changing from fine crescents to quarter phases, where about half is illuminated. New or full phases are impossible to observe – and it's dangerous to attempt – as the planet appears too close to the Sun when they occur. The superior planets (Mars, Jupiter, Saturn, Uranus and Neptune), are only seen between gibbous and full phases. Planets beyond Mars appear virtually full all the time because, as they are so far away, the relative Sun and Earth separation has little effect.



◄ **Why not customise your completed planetary phase model with more planets?**

Get modelling

These phenomena are most readily understood with a model or diagram so, as an interesting, educational exercise, this project is a home-built planetary phase model. You'll have a good talking point and an attractive object for display. You can download and print an overlay for the main disc, which has markings to help you to understand some of the terminology and alignments. Spheres with painted surfaces represent the Sun and planets and help to explain the phases we observe through our telescopes.

Our model includes the Sun and Earth, with one sphere representing an inferior planet and one superior. Earth is fixed to the main disc, on which the printed overlay is stuck. A central shaft runs through this disc. The planets are attached to arms (one above and one below the disc) which pivot on this vertical shaft. The shaft is glued into another disc, the base of the model, and the Sun is glued on top.

The planets and Sun are made from wooden balls, bought from a craft shop. The planets are painted yellow and black, and fixed to their respective arms with the yellow side facing the Sun representing their illuminated face.

Some basic principles can be understood straight away when using the model; for example, you can see why the inferior planets can only be observed from Earth just before or just after sunset. You can also see how the apparent size of the closest planets, Venus and Mars, varies as their distance from us changes.

Other phenomena that can be seen include the maximum elongations of inferior planets (the furthest apart they can appear from the Sun in the sky) and the positions of conjunction and opposition, where the planet, Sun and Earth are in a straight line.

In our model, the inferior planet passes across the face of the Sun (observed from Earth) as it orbits. This is called a transit. Because the planes of the actual orbits of Earth and planets are slightly inclined to one another, this rarely happens in reality.

You can also customise your model to show more planets or add the Moon, orbiting Earth.

Mark Parrish is a bespoke designer. See more of his work on his website: buttondesign.co.uk

Tools and materials

- Marking out tools (ruler, compasses, pencil), scissors, coping saw, drill and small bits.
- A small quantity of 6mm MDF or equivalent (approximately A4 size), a similar-sized piece of material (or thicker) for the base, and a short length of dowel (6mm diameter). An offcut of clear plastic is optional for the inferior planet arm – we used an old CD case.
- Small wooden balls – we used an 18mm-diameter ball for the Sun and 12mm for the planets. Cocktail sticks, wood filler, craft glue and sandpaper.
- For the finish you will need some yellow and black acrylic paint for planets, and a suitable spray paint for other parts.

More **ONLINE**

Download templates and additional photos for this project. See page 5 for details

ALL PICTURES: MARK PARRISH

Step by step

Step 1

Print off the template (see page 5) and use it to mark out main parts. Cut the MDF with a coping saw and smooth all edges. The clear acrylic is brittle so support it by clamping thin scrap wood to it when cutting (you cut though this at the same time).

Step 2

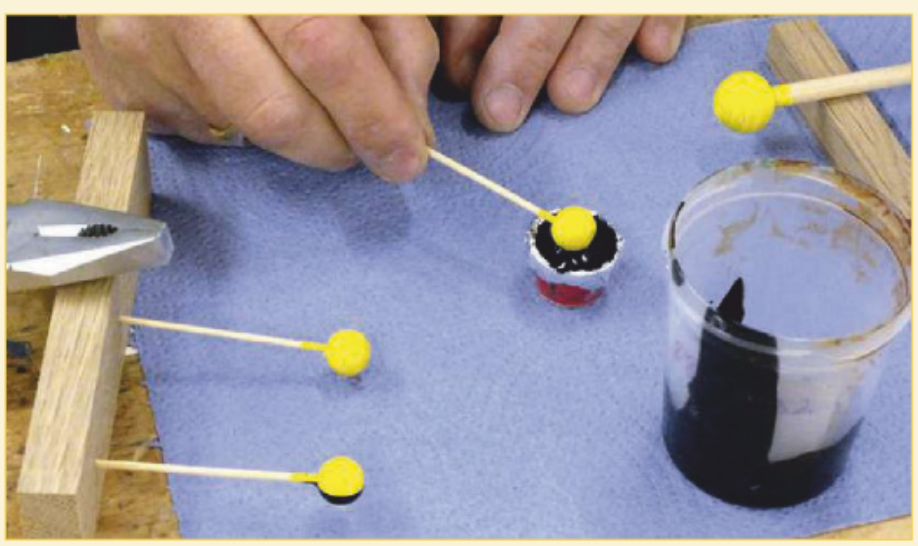
Measure the dowel you are using and carefully drill holes in the centre of the discs and planet arms. You also need holes for the cocktail sticks which support the planets. You may need to enlarge the hole in the Sun ball to accommodate the dowel.

Step 3

To produce a nice finish and ensure the parts rotate smoothly, spend some time rubbing down and applying a nice spray paint finish. Print off, cut out and stick down the illustrated overlay disc – we laminated ours. Make sure the Earth hole is lined up.

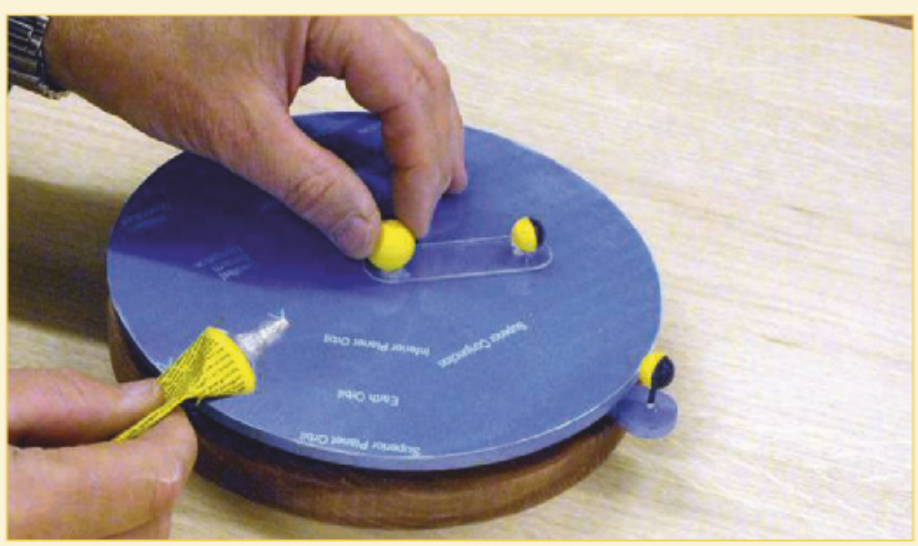
Step 4

The smaller wooden balls need to be stuck to the cocktail sticks. The larger Sun ball is temporarily mounted on a piece of dowel for painting. Fill any exposed holes with wood filler. When dry, rub down until smooth and paint yellow all over.



Step 5

Painting the dark sides of the planets is fiddly so dip them in a cap full of the black paint (a little thinned with water) so that half gets coated instead. Poke the sticks into holes in some scrap wood and let them dry. Remember to leave the Sun all yellow.



Step 6

Glue the dowel into the base first. When assembling the rest of the model, check the parts turn smoothly before gluing on the Sun. Trim the cocktail sticks so that the horizontal centrelines of the Sun and planets align when they are stuck in.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Revealing Mercury and Venus on the move

Use wide-field photography to plot how planets appear to move relative to each other

▲ **Join the dots: trace the path of Venus and Mercury near a crescent Moon with a wide-field camera**

ALL PICTURES: PETE LAWRENCE

There are various ways to carry out planetary imaging. If you have a telescope with a long effective focal length then it's possible to produce images of our neighbouring worlds large enough to show detail on their surfaces or atmospheres. However, it takes time, patience and a fair bit of investment to do this well.

If you don't have a planetary imaging setup, there is still a lot you can do to reveal our Solar System's wonders. Here, we're doing just that by imaging Mercury and Venus in the twilight with a wide-field camera.

Wide-field setups won't show planetary detail. The imaging scale is so small that the best you can hope for is a bright dot against an evening sky. If this doesn't sound too exciting hold on, because if you do it right that dot can tell you a lot about how the planets appear to move relative to one another.

You'll need to dig deep into your photographic repository for this project as it requires skill both to image the planets well enough to see them, to calculate the framing so they don't disappear out of shot later on in the sequence and, most importantly of all, to be artistic in your choice of foreground.

Choosing your foreground is complicated by the fact that you'll need to repeat your setup, ie, tripod-positioning and camera-framing over the course of the month. So, for example, it's no good framing with the Eiffel Tower in shot if you're only in Paris for a day.

Then there's the fact that the evenings are getting lighter. This is a real issue for carrying out the type of composite where you are required to photograph your subject(s) at the same time of day over the course of many days. Get the time wrong and you'll have distinct dots against a dark background sky at the start of the sequence, but they will be lost against a bright twilight or even with the Sun up at the end.

Just to add more complexity, February in the UK isn't always the best month for astronomy due to the weather. If you do miss any shots, it's worth bearing in mind that this is not the end of the world and in some respects enhances the reality of the result.

Follow the step by step guide and you will be in with a chance of revealing how the planets move over time. As an added bonus, a crescent Moon will join the show towards the end of February and this will provide an extra burst of interest for the sequence's end.

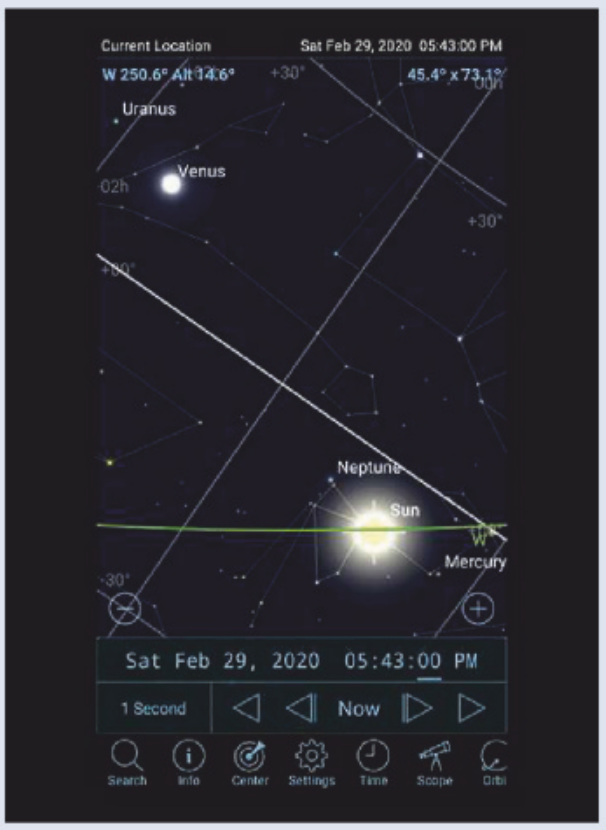
All you need to succeed here is a camera sensitive enough to record Venus, and hopefully Mercury, as dots. It needs to be capable of covering the area worked out as shown opposite. You'll also need some method of holding it still in exactly the same place each time you take a shot. Although a DSLR or MILC (mirrorless interchangeable-lens camera) fits this bill, it also leaves the door open for smartphone cameras.

Recommended equipment: a camera with a wide-angle lens, a tripod

Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

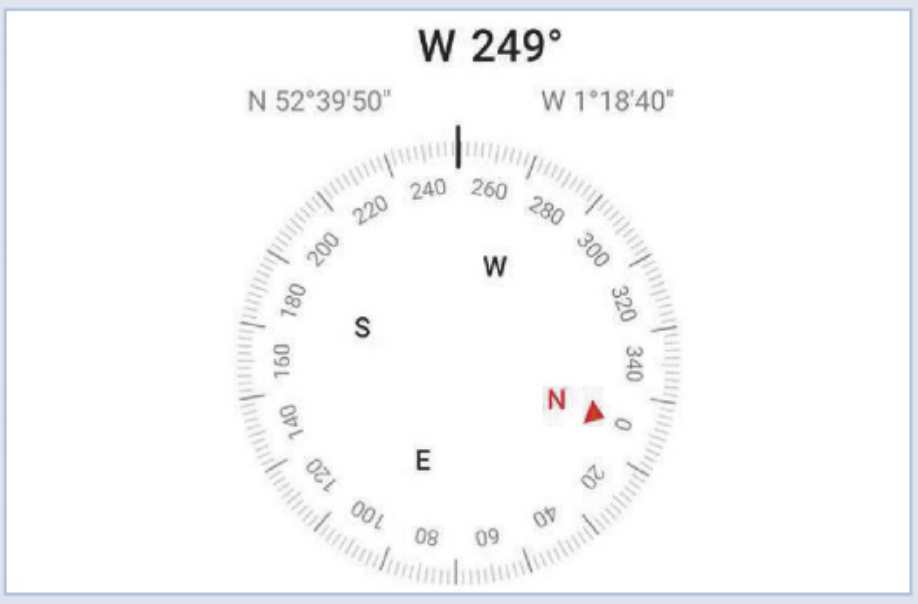
✉ Send your images to:
gallery@skyatnightmagazine.com

Step by step



Step 1

A Planetarium program can be used to plan your shot. Set it to sunset on 29 February (17:43 UT, central UK). Advance time by say 40 minutes. Note the azimuth and altitude of Venus (altitude 32° azimuth 243° (west-southwest) from central UK). Now set the date to 1 February but leave the time alone. Note where Venus is now (altitude 19°, azimuth 236°).



Step 2

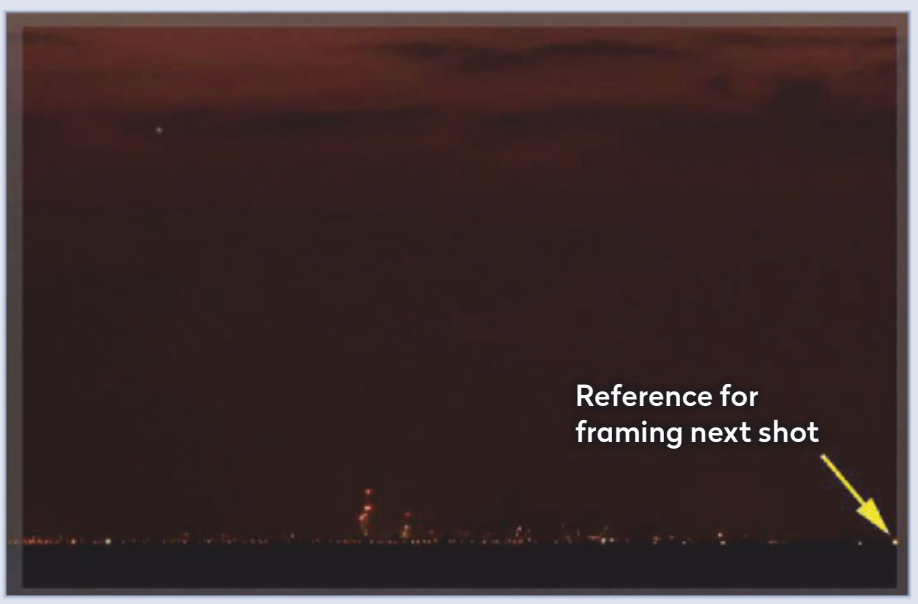
Mercury appears in the middle of the month; run the simulation to ensure it will be visible for you. It disappears around 20 February around azimuth 262°. Pick a shoot location that is easy to repeat over the month. Identify the middle azimuth value of the range you need to cover. For example, between 236° and 262° this would be 249°.

Step 3

Choose a lens for the sky area required plus breathing space. From Steps 1 and 2, we need 32° of altitude and 13° of azimuth. With horizon and breathing space, expand to a minimum of say, 45° by 30°. This would be covered by a 28mm lens using an APS-C camera in portrait orientation or 18mm in landscape.

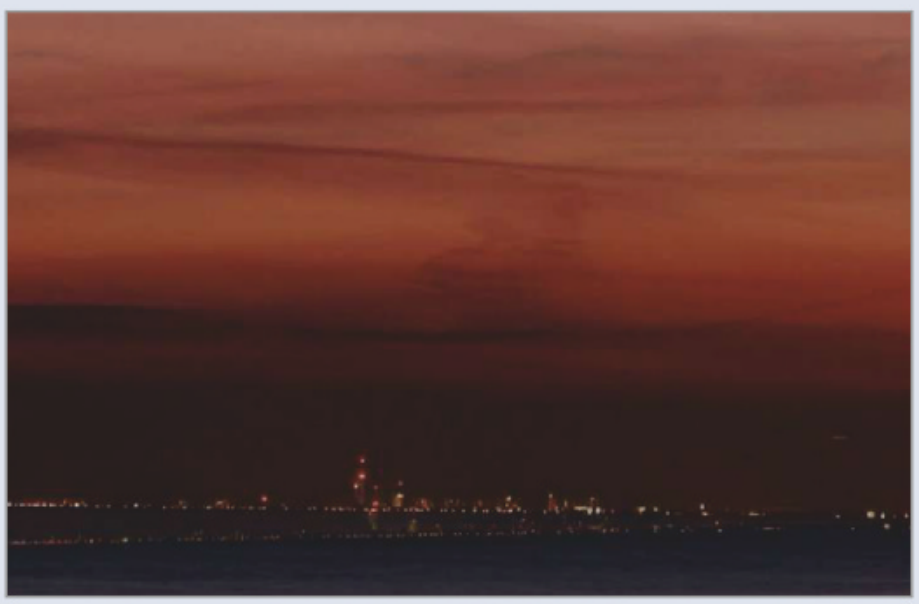
Step 4

Camera settings will depend on the time of shot, lens selected and sky quality. Try with a low ISO of 200–400. Set your f/number to its lowest value then close by a stop or two. Choose an exposure that doesn't over-expose the background sky (no white). To prevent trailing keep exposure times below 10 seconds.



Step 5

Centre on the azimuth calculated in Step 2, framing your shot with a small strip of horizon at the bottom for context. It helps to align one frame edge against something on the horizon for reference in forthcoming shots. Photograph at the time calculated in Step 1 (eg, sunset + 40 minutes), repeating on each evening at the same time.



Step 6

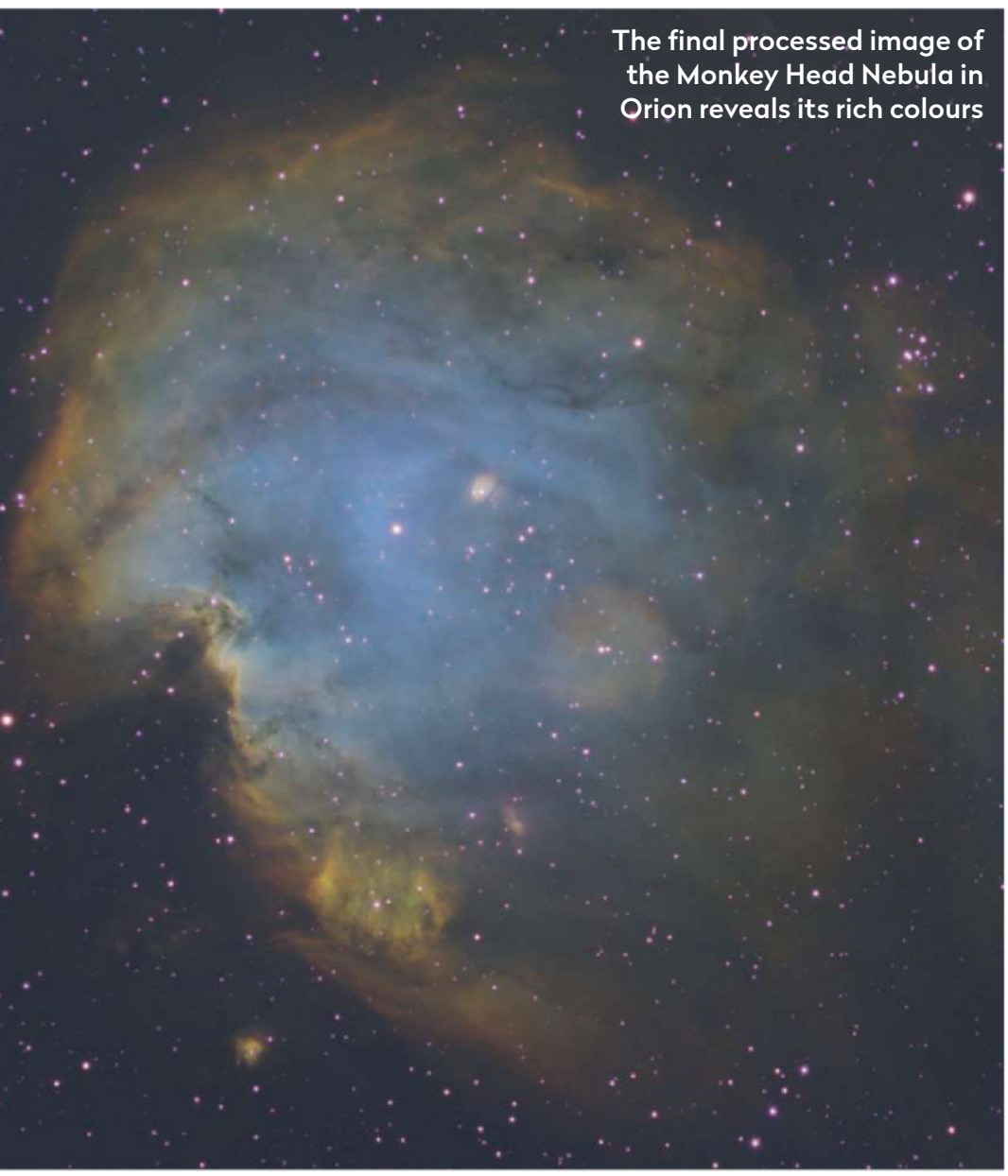
At the month's close load each shot into a layer-based graphics editor as a separate layer. Align on the horizon. Set the blend mode of all layers except the bottom one to lighten, allowing planets to appear. Darken bright frames to avoid sky clash. The result should show how the planets move relative to the horizon over the month.

Expert processing tips to enhance your astrophotos

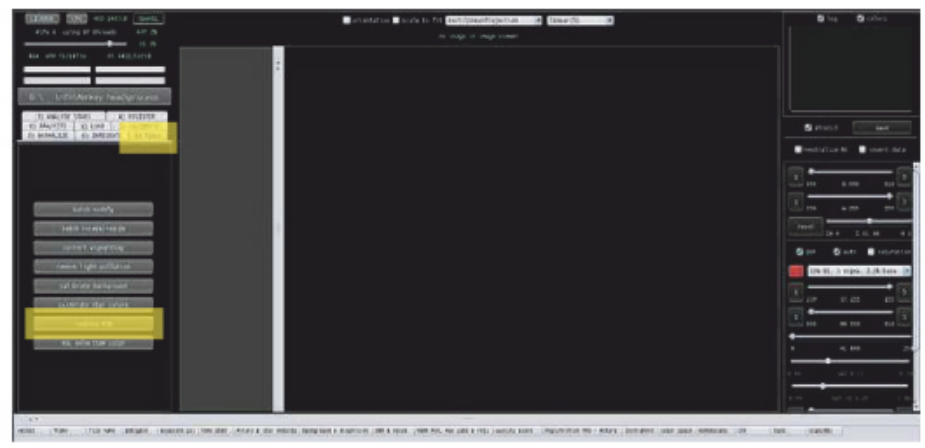
ASTROPHOTOGRAPHY PROCESSING

Astro Pixel Processor and the Hubble Palette

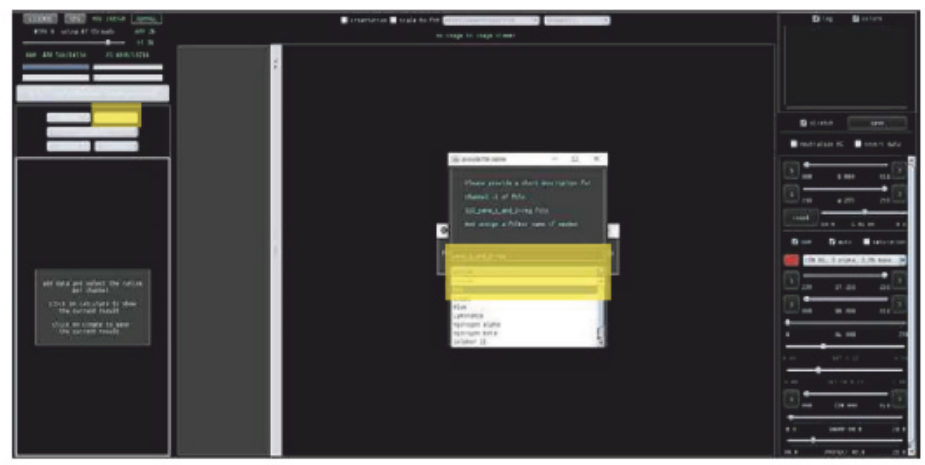
How to process your images of a nebula to reproduce the famous Hubble Palette



The final processed image of the Monkey Head Nebula in Orion reveals its rich colours



▲ Stage 1: once the Astro Pixel Processor 'Tool tab' is open click on 'Combine RGB' to begin creating the narrowband image



▲ Stage 2: use the central box to assign a channel to each narrowband image. The red channel takes the Sulphur II data

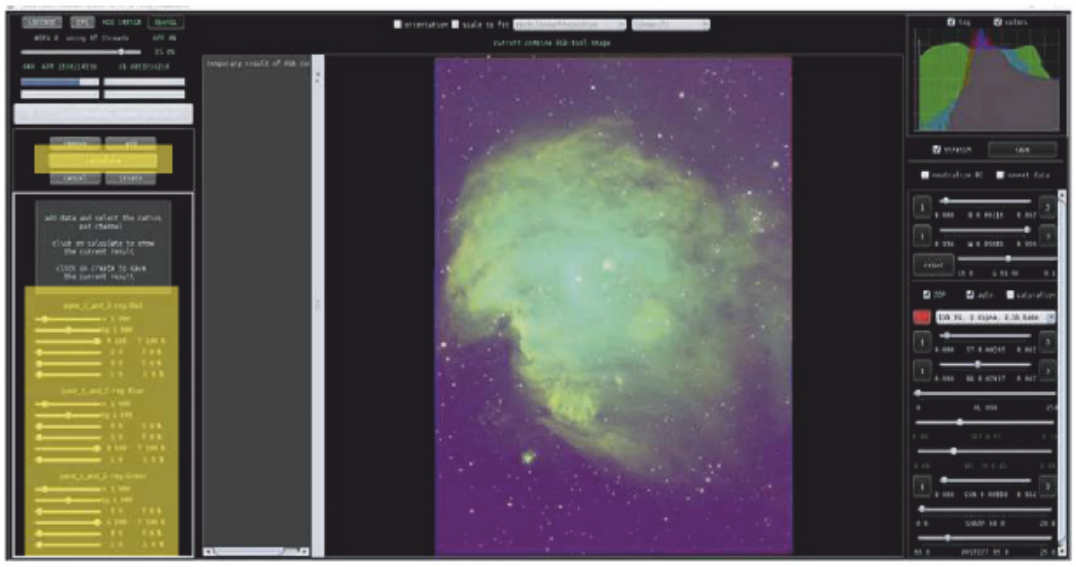
The Hubble Palette is easily recognisable, thanks to the iconic Hubble Space Telescope (HST) image of the 'Pillars of Creation', originally from 1995. While this showed the pillars in never-before-seen detail, it also showcased a colour palette that many emulate. The Hubble Palette is created by using narrowband filters and assigning the data captured with each narrowband-filtered channel to one of the red, green or blue colours in an RGB image.

ALL PICTURES: SARA WAGER

Sara Wager is an astrophotographer who images from Spain. Follow her on @swag_astro

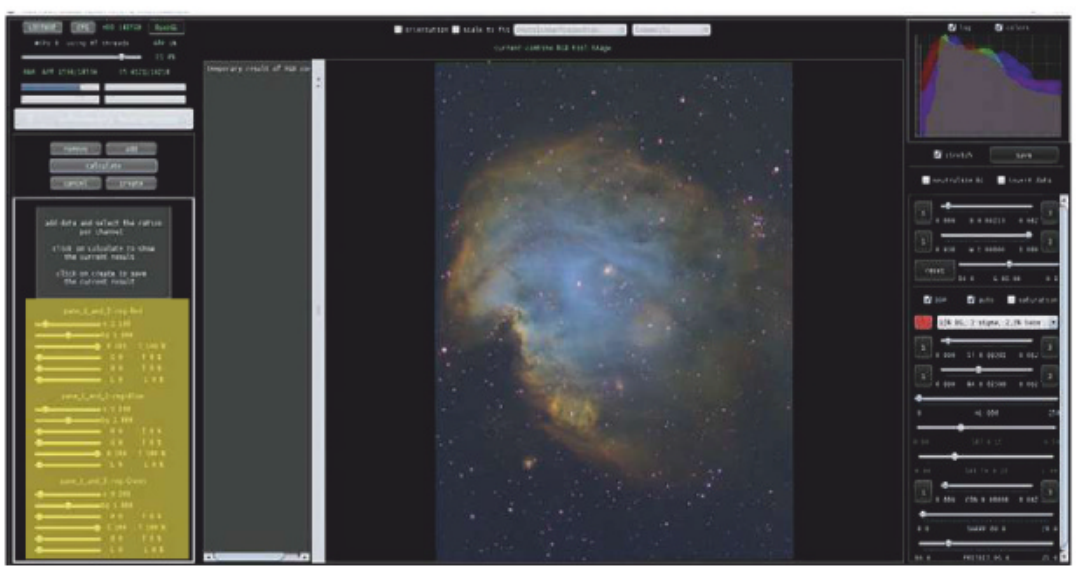
We start having calibrated, integrated and registered our data in Astro Pixel Processor (APP), so that we are left with three individual images, one for each narrowband filter: Hydrogen-alpha (Ha), Sulphur II (SII) and Oxygen III (OIII). These images are currently monochrome and we need to combine them into appropriate colour channels in order to make a start on the Hubble Palette.

Firstly, open APP and go to '9) Tools tab'. Click on this and then click on 'Combine RGB' (see Stage 1). Click 'Add' and this will bring up a central box for you to assign the filtered images to the RGB channels. The traditional Hubble Palette assigns Sulphur II to the red channel (R) (see Stage 2). Continue with this step again and assign the Hydrogen-alpha image to



▲ **Stage 3: the first combined image produced by the assigning channels**

◄ **The Monkey Head Nebula image (above) needs more work as the nebula appears green and the background is magenta**



▼ **Stage 4: adjusting the sliders related to each colour channel will transform the colours in the image**

the green channel (G) and the Oxygen III image to the blue channel (B). Make sure that you are combining FITS files as these are not going to deteriorate in quality at all and so will help your image as you progress further along the steps of image-processing.

Click 'Calculate' and you will get your first combined image (Stage 3). You can see in our example of the Monkey Head Nebula that the colours need a lot of work; the overall nebula is green and the background is magenta. In the box highlighted in yellow each filter is assigned its colour channel and the sliders show the 100% combination of each filter into each channel.

After calibration and integration of your narrowband data, it can be difficult to tease the colours out because it is almost always predominantly green. This green tint is because the hydrogen-alpha data is almost always so much stronger than the other narrowband data. We need to tone down the green and increase the strength of the other two colours. Astro Pixel Processor (APP) has a process that, while not specifically for this purpose, can be used to get a good starting point for subsequent processing.

Colour coordination

Now we look at the sliders related to each channel. We are going to lower the x value of the G channel to 0.2 and increase the x value of B and R channels to 1.100. This is going to get the more traditional colours, although the stars will tend to be magenta after this colour shift. These x figures work well with this data. It is worth noting that as each target has different strengths of Ha, SII and OIII data, these figures will not always give the same results – there is a degree of experimentation. But the theory is the same, you should decrease the strength of the G channel and increase the intensity of the B and R channels (Stage 4).

With regards to the magenta stars (see final image, far left), some are happy to leave them as it is a natural colour shift of the process we have done, but others would rather get rid of the colour and would prefer to either make them a more natural colour or whiten them. If a white colour is preferred then normal RGB data will be required. These will only need to be short exposures as you are only after star colour in the data. As an alternative, you could process a two-colour image using Ha and OIII data, to get a more natural star colour, which you could then add to your Hubble Palette data at a later stage. These two methods can be very difficult to add successfully. To get whiter stars, we prefer to remove the magenta tint in Photoshop, use Filter›Noise›Reduce noise. Ensure 'Reduce colour noise' is set to 100% and repeat this a couple of times to reduce the magenta stars.

From this point on you have the great beginnings of a Hubble Palette image. You can save it as a FITS or TIFF image and then use your preferred software to continue processing it.

3 QUICK TIPS

1. Remove magenta stars in PixInsight with PixelMath or online actions.

2. On the right of the screen in APP tick 'Stretch' and press 'Save', this saves the image you have on your screen.

3. Add a luminance layer to improve your image. Desaturate your Hubble Palette image and process it as a monochrome luminance image. You can then add this later.

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More ONLINE
A gallery containing these and more of your images

◁ Moon mosaic

Craig Towell, Bristol, 21 September 2019

Craig says: "This six-pane mosaic of the lunar northern hemisphere was captured from my back garden in Bristol at 4am. The Moon was high in the sky, which meant the image was sharp. I captured six individual panes to create the mosaic. Each pane was 5,000 frames and the best 10 per cent were stacked. Exposure was set to 10ms with gain at 100 (2%) and I used the full sensor size, yielding 63 frames per second. All the frames were captured through a red Baader filter to help steady the seeing."

Equipment: Altair Astro GPCAM3 290M mono camera, Fullerscopes 8.75-inch, f/7.5 Newtonian, Sky-Watcher EQ6 mount **Exposure:** Six panes, each 5,000 frames **Software:** FireCapture, AutoStakkert!, ImPPG, MS Image Composite Editor (ICE)

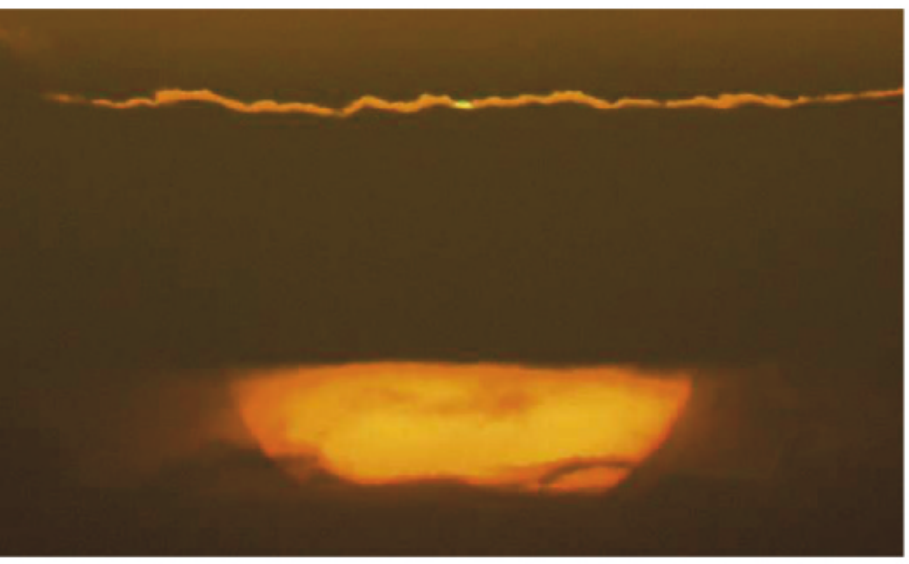
Craig's top tips: "Make sure you have plenty of hard-drive space (at least 250GB). For this image I intended to capture the entire Moon but ran out of disk space. Set exposure on the brightest part of the Moon and just below saturation. Focus on the high-contrast terminator and zoom in – spend time getting it right. Then leave alone, otherwise any changes between the panes will be obvious in the stitched image. Experiment with filters and work quickly. The terminator crosses the Moon's face quickly, so capture the terminator and collect the rest of the Moon within an hour."

The Lion Nebula ▷

Douglas J Struble, Taylor, Michigan, US, 4 & 19 September 2019

Douglas says: "In capturing Sh2-132, the Lion Nebula, in this bi-colour Ha and OIII palette I wanted to pull out more OIII than I have seen others do. I live in a dark-sky Bortle scale 7 area (see page 62), and OIII is more sensitive to light-pollution than other narrowband filters. I use an Astrodon 3nm OIII filter, which really helps."

Equipment: ZWO ASI 1600MM mono camera, Stellarvue SV70T apo triplet refractor, Orion Mount Atlas Pro mount **Exposure:** OIII 311x120", Ha 317x120" **Software:** Sequence Generator Pro, PixInsight, Photoshop



△ Green flash

Dave Walker, Billinge, Merseyside, 26 November 2019

Dave says: "I went up to Billinge Lump to try and capture a very new Moon, but it turned out to be too cloudy next to the horizon for that. Instead, that same cloud provided an interesting sunset, so I began to shoot and, to my surprise, caught this subtle green flash surrounded by the intense orange sunset clouds."

Equipment: Canon EOS 700D DSLR camera
Exposure: ISO 400, 1/1000"

◁ The Orion Nebula

Derek Foster, Sheffield, 18 November 2019

Derek says: "I had just finished imaging the Triangulum Galaxy, M33, and noticed that the Orion Nebula, M42, had popped up above the horizon. I managed 50 minutes of lights before it was obscured by neighbouring houses, but I'm very pleased with the result."

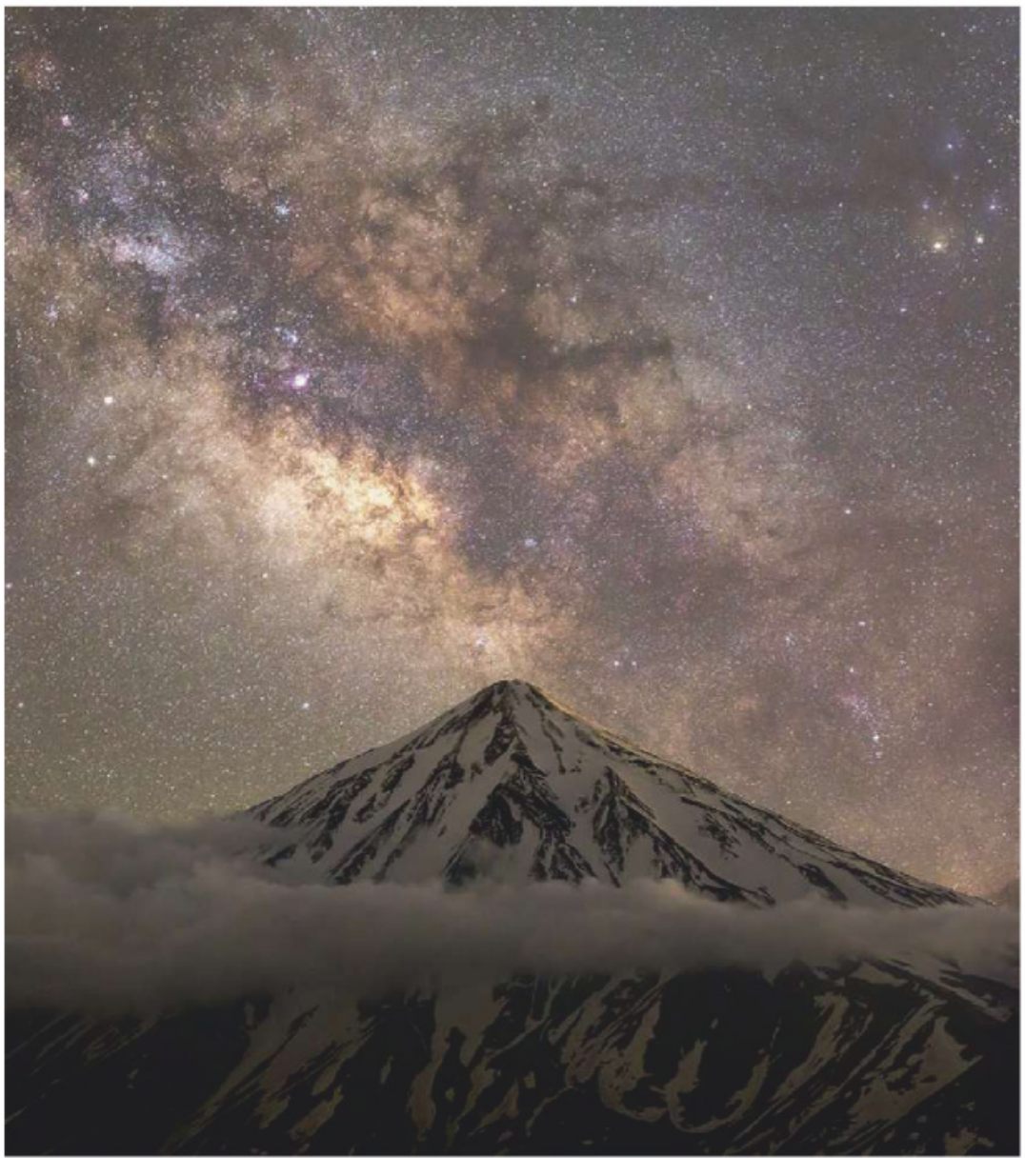
Equipment: ZWO 294MC-Pro camera, TS-Optics Photoline 80mm triplet apo refractor, Sky-Watcher HEQ5 Pro Go-To mount **Exposure:** 20x150" lights, 50x darks/dark flats/flats **Software:** AstroPhotography Tool, Astro Pixel Processor, Photoshop

◁ Barnard's Loop

Stuart Fraser, Wensleydale, North Yorkshire, 28 October 2019

Stuart says: "I had been up all night imaging the Heart and Soul Nebulae when Orion began to appear from behind some trees at around 3am. Low-lying cloud started to roll in, which meant that out of approximately two hours of data only around 60 per cent was useable."

Equipment: Canon EOS 450D DSLR camera, Sky-Watcher Star Adventurer mount
Exposure: ISO 400, 65x80" **Software:** DeepSkyStacker, Photoshop, Lightroom



△ The Rosette Nebula

Steve MacDonald, Cyprus, 21–25 November 2019

Steve says: "This was the first image I took in Ha (Hydrogen alpha) a few years ago and I've been waiting to do a colour version for a while. I wanted to minimise noise so I took 10 hours in each filter, SII, OIII and Ha. I then combined the three filters to recreate the classic Hubble palette."

Equipment: Moravian G2-8300 mono camera, Sky-Watcher Esprit 100 apo refractor, Sky-Watcher EQ6 mount **Exposure:** Ha, SII and OIII: 30x1,200"
Software: Sequence Generator Pro, PixInsight, Photoshop

◁ Mount Damavand and the Milky Way

Majid Ghohroodi, Iran, 8 June 2018

Majid says: "Mount Damavand is the highest volcano in Asia and one of the national symbols of Iran. Bad weather and difficult access meant it was challenging to reach the position to take this shot. Finally, after a five-hour steep hike with my heavy backpack, I captured this."

Equipment: Canon EOS 6D DSLR camera
Exposure: ISO 6,400, 10", 4-frame panorama
Software: Adobe Photoshop, PTGui

△ The Andromeda Galaxy

Brian Cummins, Virginia, US, 1, 2, 24 & 25 November 2019

Brian says: "I have always wanted to image Andromeda, the first galaxy I found with a telescope, but I was limited by my equipment's field of view. I recently decided to try to capture it as a two-panel mosaic, which I did over four nights at Sky Meadows State Park in Virginia."

Equipment: ZWO ASI 1600MM-Pro mono camera, Orion 8-inch Newtonian, Sky-Watcher NEQ6 Pro mount
Exposure: 14-hour total, LRGB integration time
Software: Sequence Generator Pro, PixInsight

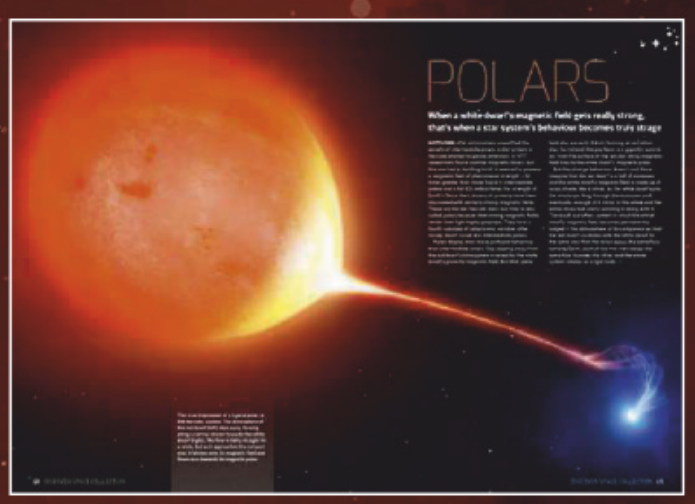
The Helix Nebula ▷

Kfir Simon, Israel, June & July 2019

Kfir says: "This is a combination of two scopes used remotely: the Chilescope and the Hypergraph at Tivoli Astrofarm in Namibia. I had data from Namibia, but wondered what I could get from Chilescope's 1m lens at a focal length of 7m."

Equipment: FLI ProLine 16803 CCD camera, Chilescope Ritchey-Chrétien 1000, Tivoli 16-inch f/8 Hypergraph
Exposure: Chilescope: Ha 120', L 30'; Hypergraph: Ha 4h; RGB 30' each; OIII, SII 60' each **Software:** Photoshop

SPECIAL EDITION



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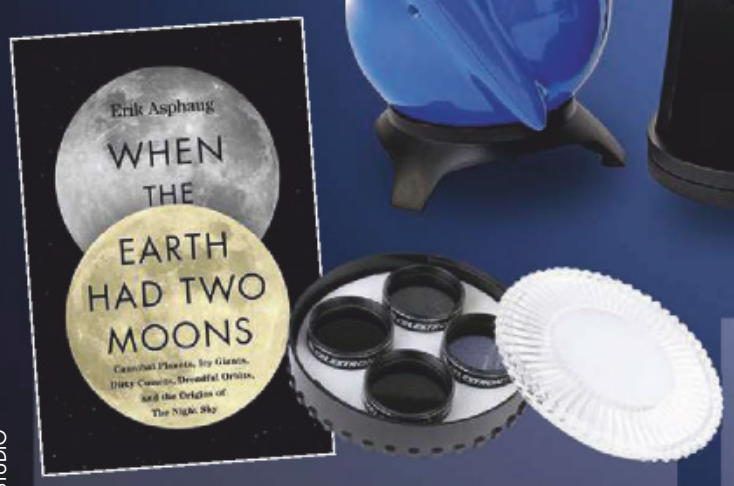

PLUS: Books on when Earth had two Moons, the science of Stephen Hawking, and a roundup of latest gear

HOW WE RATE

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★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

Our experts review the latest kit

6 OF THE BEST

Telescopes for kids

Kickstart a lifetime of stargazing with these starter telescopes from £52.99–£90

WORDS: CHARLOTTE DANIELS

Sky-Watcher Infinity-76P

Price £52.99 • **Weight** 1.7kg • **Extras** 30x erecting eyepiece
Supplier Optical Vision Ltd • **Tel** 01359 244200 •
www.opticalvision.co.uk

The Infinity-76P is designed for the youngest astronomers and has a distinctive shape that resembles a spaceship. It comes with stickers for decoration and the cardboard box can be folded up to use as a carry case.

This is a low-power telescope that can be assembled in minutes; pop the scope onto the curved base, insert the eyepiece and away you go. The motion of the Infinity-76P is impressively smooth on its mount although it can't be locked in position, which could pose an issue when small hands make a grab for the eyepiece and move the field of view.

Overall, this is an intuitive scope to operate and the erecting eyepiece allows for daytime use, which adds to its appeal. Viewing quality is what you'd expect for such a small system, however, we had pleasing sights of the Moon with enough crater detail to keep young minds interested. There isn't much to break or misplace and we found we could also pack the Infinity-76P away quickly, which can be a bonus if interest quickly wanes.

VERDICT

A robust first telescope that can be assembled quickly
FOR Simple enough to encourage interest
AGAINST Unable to secure telescope for viewing

OVERALL SCORE ★★★☆☆

Sky-Watcher Heritage-76

Price £62.99 • **Weight** 1.75kg • **Extras** Finderscope and two eyepieces (10mm & 25mm) • **Supplier** Optical Vision Ltd
Tel 01359 244200 • **www.**opticalvision.co.uk

The Heritage's overall finish is excellent and looks attractive. For instance, rather than a plastic base (commonly found on toy telescopes), this one is wooden and gives stability to the setup without making it cumbersome. Movement of the scope in all directions is fluid, meaning that you can swing from one object to the next with minimal effort. The 300mm focal length allows a decent field of view for popular objects such as the Moon, the Andromeda Galaxy and the Pleiades.

The Heritage-76 comes supplied with functional, uncomplicated accessories suitable for beginners – a finderscope and two eyepieces. While the finderscope is plastic and perhaps a little cheap the eyepieces are fair quality.

In use, the focuser allows a decent level of control and is easy to manage for slight adjustments. Assembly and disassembly remain simple, and while the instructions are in-depth they are easy to interpret. Once you've perused them, it is unlikely you'll need to look at them again. Furthermore, the compact setup stays as a single piece and won't clutter up a bedroom.

VERDICT

Easy to use, with accessories that offer rewarding views
FOR Great movement; mount locks in place
AGAINST Difficult to use finderscope for overhead objects

OVERALL SCORE ★★★★☆

ALL PICTURES: @THESHED/PHOTOSTUDIO

Orion FunScope 76mm tabletop reflector

Price £79.99 • **Weight** 1.8kg • **Extras** Orion MoonMap 260, two eyepieces (20mm & 6mm), 2x Barlow lens
Supplier Orion • **Tel** 0800 041 8146
https://uk.telescope.com

The FunScope comes with a Moon map, which invokes a sense of exploration and helps young astronomers to navigate around lunar craters and seas. It's almost identical to the Heritage-76 in design, but introduces a slot-in EZ Finder II Reflex Sight instead of a finderscope, which we think is a better addition. Once there's an eyepiece attached, however, the setup becomes top-heavy and doesn't balance. But this issue is not overly important since the telescope has a locking mount.

We swung this scope over to the Pleiades and while the stars were sharp at the centre of the field of view, there was distortion at the edges. Nevertheless, it proved good at lunar observation and the Moon map will ensure children want to use this again.

Something to take into account with this and all miniature or tabletop reflectors, including the Heritage-76 and Meade LightBridge tested here, is that it becomes difficult to locate overhead objects using the finderscope. The problem is that when the scope is vertical, there is no room to position your head between the telescope and the table.

VERDICT

An easy to use mini scope that performs well
FOR Stable wooden mount, with good accessories
AGAINST Slight distortion from eyepieces

OVERALL SCORE ★★★½☆

Meade LightBridge Mini 82mm

Price £69 • **Weight** 1.75kg • **Extras** Red-dot finder, two eyepieces (9mm & 26mm), 2x Barlow lens, planetarium software
Supplier Hama UK • **Tel** 0333 123 4262 • **uk.**hama.com

Much like the Heritage-76 and Orion FunScope, the LightBridge is a tabletop telescope, though it has a bit more aperture at 82mm. This increases light sensitivity and allows it to show more detail from the objects you want to observe while still remaining compact.

This time, we found a 2x Barlow lens and red-dot finder (battery supplied) accompanying the eyepieces. The kit also comes with a planetarium app you can install on a computer. The red-dot finder also has a nice wide screen, which increases its ease of use. While stars could be sharper, the eyepieces are of fair quality. The instructions are not child-friendly at first glance, with a large booklet and some intimidating-looking text accompanying the kit. But further investigation revealed that many of these instructions don't apply to this model so can be disregarded.

If we're being picky, the movement of the base could be smoother and the finish could be improved. That said, the LightBridge does what it's meant to do and provides a worthy first impression for young, first-time astronomers. ▸

VERDICT

A starter kit that will likely be used more than once
FOR Looks good and performs well
AGAINST Base not as fluid to rotate

OVERALL SCORE ★★★★☆

6 OF THE BEST

Celestron AstroMaster LT 60AZ refractor

Price £90 • **Weight** 5.4kg • **Extras** Erect image diagonal, two eyepieces (20mm & 10mm), Moon filter and smartphone adaptor
Supplier D Hinds Ltd • **Tel** 01525 852696 • **www.**dhinds.co.uk

The AstroMaster is a refractor and the first of the six scopes on test group that looks like 'a proper telescope'. By that we mean it's the traditional telescope-on-a-tripod setup. The kit is robust but lightweight and only comes in two main parts, allowing for quick and straightforward assembly. We needed a screwdriver, which is a slight minus, but it is still ready in minutes. The eyepieces each provide sharp views of stars and great lunar detail with minimal distortion at the edges. The tripod is light and while the equipment tray provides stability, care is needed not to nudge and move the setup when it's in use. The supplied smartphone adaptor really grabbed our attention, as it allows users to delve into the world of astrophotography as well as dabble with astronomy. This will enhance the experience for young users, especially once they have provided an image that proud parents can post on social media and share. The Celestron is versatile enough for children and young adults, meaning it'll last for some years.

VERDICT

A great first refractor to feed early interest
FOR The smartphone adaptor is a winning addition
AGAINST Tripod guiding handle limits full movement

OVERALL SCORE ★★★★½

Bresser Junior 60/700 AZ1 refractor

Price £89 • **Weight** (incl. case) 5.1kg • **Extras** three eyepieces (4mm, 12.5mm & 20mm), compass and planisphere • **Supplier** Telescope House • **Tel** 01342 837098 • **www.**telescopehouse.com

The fact that this Bresser telescope, tripod and mount all fit neatly into a carry case is a definite bonus and gives it a level of portability. But once this 60mm refractor is assembled, we doubt it'll be taken down again. The reason being it's constructed from about 20 parts that require assembly, making this more of a 'Meccano mission' than other kits. For instance, while we often expect a tripod to unfold as a single piece with telescopic legs, here the three legs are separate and the extendable elements of each one have to be put together. Assembling the scope took 20 minutes, which isn't unreasonable, given the number of screws and bolts that comprise the build. But it's unlikely you'll want to pack it away again any time soon.

The Andromeda Galaxy looked fairly good through this scope but the eyepieces gave a very narrow field of view. We did like the compass and planisphere, which are undervalued tools in an often technology-focused hobby. These are a nod to some basic and important aspects of amateur astronomy.

VERDICT

Performs well when set up, but assembly requires patience
FOR Lots of useful accessories
AGAINST Setting up is one for the parents

OVERALL SCORE ★★★☆☆

ALL PICTURES: @THESHED/PHOTOSTUDIO

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Stellina Observation station

A futuristic, fully automated astrophotography scope that's almost hands free

WORDS: PAUL MONEY

VITAL STATS

- **Price** €3,999
- **Optics** 80mm ED doublet refractor
- **Focal length** 400mm (f/5)
- **Mount** computerised robotic altazimuth
- **Ports** 1 USB type-C (power), 2 USB type-A (image storage; not included)
- **App control** Stellina app; targets include galaxies, nebulae, clusters and the Moon
- **Sensor** Sony CMOS IMX178
- **Extras** Integrated dew heater and de-rotator, fabric shroud, bubble level, Gitzo Systematic tripod, 10,000 mAh battery, cables
- **Weight** 11.2kg
- **Supplier** Vaonis
- **Tel** +33 467 593022
- **https://** vaonis.com

Every so often a revolution takes place within astronomical equipment. First it was the telescope, then equatorial mounts, the advent of astrophotography and in the last few decades, Go-To systems of ever-increasing complexity. Now comes Stellina, a fully automatic altazimuth system that can take images of deep-sky objects without any of the standard paraphernalia of guide scopes, equatorial mounts, laptops and external cameras. It appears to be everything you need in a compact, sleek, white and black rectangular casing, which is mounted on a tabletop tripod. It also promises to image the Universe with hardly any input bar a couple of taps on a tablet or smartphone screen. We were sceptical about how the Stellina would measure up, so we were eager to put one to the test.

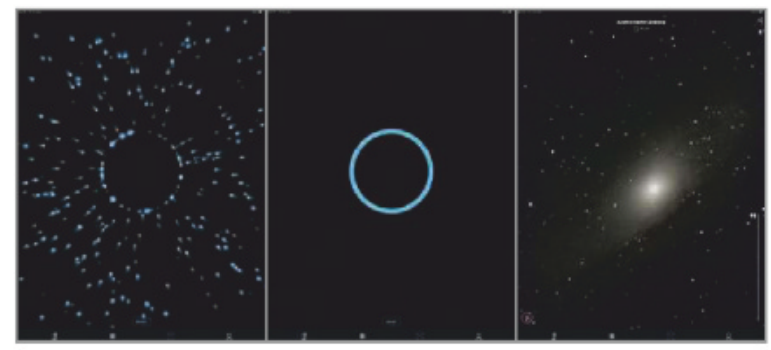
The setup certainly looks smart: a minimalist box with an optical telescope and an altazimuth fork mount fully computerised to track the night sky. The scope is an 80mm ED doublet refractor of 400mm focal length giving f/5, with an integrated dew heater to prevent it misting up. At the base of the telescope is a 6.4MP Sony IMX178 sensor with a CLS (city light suppression) light-pollution filter just in front of it, so even light-polluted skies can give reasonable results.

Assembly was quite easy, mounting it on the 'Gitzo Systematic' short tripod, while the bubble level is helpful to ensure the system is level for best operation. Power comes from a 10,000 mAh battery pack which is plugged into the battery compartment via a USB-C port. Here there's also two USB-A ports for adding flash drives to store raw images.

Create a network

Next comes the electronic setup. Download the Stellina app for Android or Apple iOS and turn on the Stellina via the round button on one side, which turns blue. It will create a Wi-Fi network which enables you to connect your device to it, before proceeding to the initialisation screen. Up to 20 other devices can be connected to share the experience, although one remains the actual controller, which is useful for groups at star parties. Stellina will then do all the set-up work for you by using GPS to set time, date and location, open the telescope and search the sky for a starry field, then auto focus the optics. Once done it is ready for you to choose a target to image. It should be noted that Stellina has an operating temperature range of 0–40°C, so observers based in ▸

Hassle-free astrophotos



Impressively, Stellina does what it says it can do. It can take deep-sky astro images of many of the brighter deep-sky objects – from galaxies to clusters to nebulae – along with the Moon. Once the target is centred, the app shows a cascade of light falling to the centre of the screen in a hypnotic animation. Once Stellina identifies the first good image, the cascade transforms into a blue circle which fades away to reveal the first crude picture. As time proceeds the deep-sky image builds up; you can either go with the suggested time, allow it to continue past it, or stop the live stacking early if you are happy enough with the image. We captured a range of targets, including the Orion Nebula, M82, the Cigar Galaxy, M1, the Crab Nebula and the Andromeda Galaxy. Although Stellina is not ideal for imaging large objects like M31, a mosaic feature is being looked into for summer 2020, so something like the whole of the Andromeda Galaxy could eventually be covered in full.

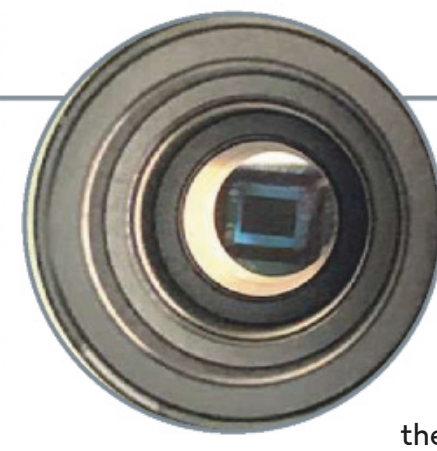
@THESHED/PHOTOSTUDIO X 3

SCALE

Optics

At the core of the optical system lies an 80mm ED doublet refractor with a focal length of 400mm giving a focal ratio of f/5. The front objective has an integrated dew heater to prevent dewing and the internal tube is baffled to help cut out stray light.

Sensor



Deep in the optical system lies the sensor, which is a Sony IMX 178 with a resolution of 6.4 megapixels, equivalent to 3,086x2,076 pixels. It's particularly sensitive in the near-infrared spectrum, which is useful for imaging nebulae. A CLS (city light suppression) filter, just in front of it, enables imaging in light-polluted urban skies.

Integrated de-rotator

With an altazimuth system it cannot follow the sky in an arc, keeping the same orientation of the view as an equatorial mount can, so an internal integrated de-rotator is included. This worked perfectly allowing for the in-built computer to stack multiple images live, often for over an hour if needed.

Stellina body

The Stellina body houses the computer, Wi-Fi adaptor and altazimuth Go-To system in a minimalist white and black fork mount. Despite packing so much in and housing the optical system, it is surprisingly lightweight and easy to handle. It is also quiet, belying the complex operations taking place.

FIRST LIGHT

KIT TO ADD

1. Flight case with wheels

2. Long Gitzo Systematic tripod

3. 20,000mAh battery (available in 2020)

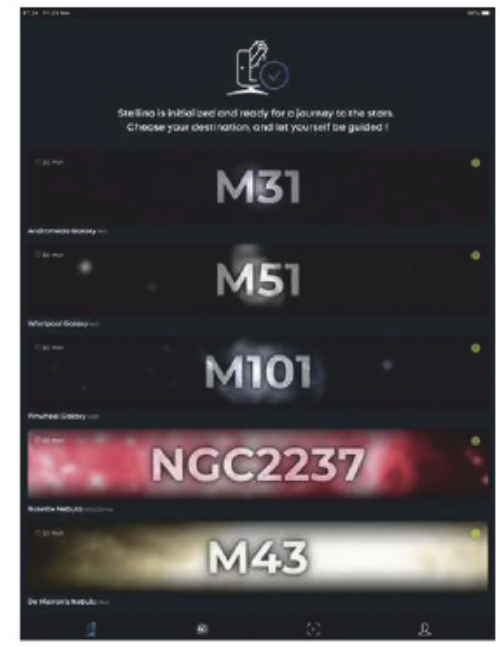
▸ colder northern climates may not be able to use it as much as they'd like if the temperature drops below freezing.

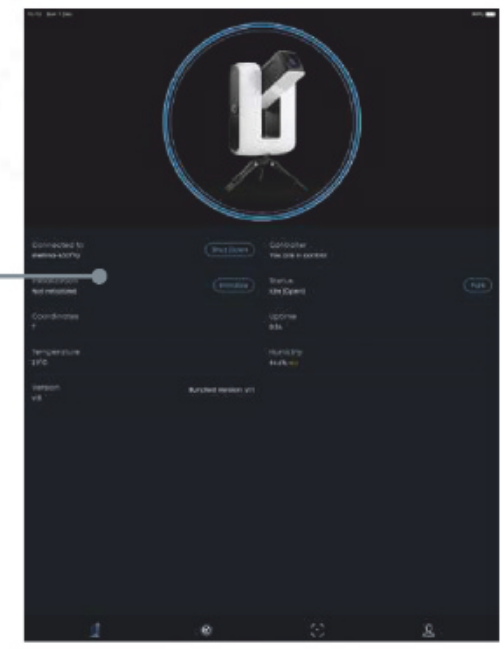
Unlike most telescopes, there is no place for an eyepiece. Instead, once Stellina is directed to a deep-sky target it spends a little time (roughly a couple of minutes) locating, then plate solving, the starfield to ensure the object selected is centred. It then automatically begins to take and stack live images. These appear on your smart device screen in a process known as 'live stacking'. Using the integrated de-rotator in the telescope, the system compensates for the rotation of the field of view automatically while the onboard computer rejects any poor images, only stacking the best to produce the final image.

Shape of the future

The Stellina app has a selection of around 100 deep-sky targets, plus the Moon. The developer, Vaonis, tells us there are plans to expand the database to include more targets, plus members of the Solar System. Each target has optimised settings which cannot be changed, but when it's left to do its work the Stellina does produce worthy results. Purist astrophotographers would probably prefer more control. However, you can stop the imaging via the app and save the image either to the device or share via social media later, while the raw images are stored on the flash drives automatically and you can process them yourself.

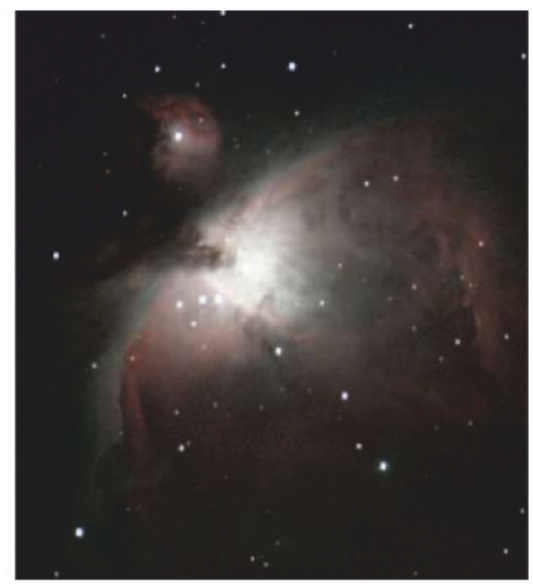
Overall, the Stellina certainly lives up to the promise of its futuristic design. It made imaging the cosmos an easy and almost effortless task and the current list of targets will keep you busy for a while. With potential upgrades hinted at by Vaonis, it may be the only system you need. While €3,999 may seem a high price, avid astrophotographers can easily spend that much on building up their equipment. So, it could be seen as making astrophotography available for anyone regardless of experience – as long as you can meet that price tag.





Stellina app

Stellina is controlled through the app which has both iOS and Android versions, downloadable from their respective stores. Once Stellina is turned on, your device connects to its Wi-Fi and allows you to initialise and control the scope. The images it takes are downloaded to your device too, and can be saved from there.



Above left: the Orion Nebula, M42, taken with a 360" exposure. Above right: the Pacman Nebula, taken with a 2,030" exposure. Left: M35 and NGC 2158 open clusters, taken with a 180" exposure

VERDICT

Assembly	★★★★★
Build & design	★★★★★
Ease of use	★★★★★
Features	★★★★☆
Optics	★★★★½
OVERALL	★★★★★

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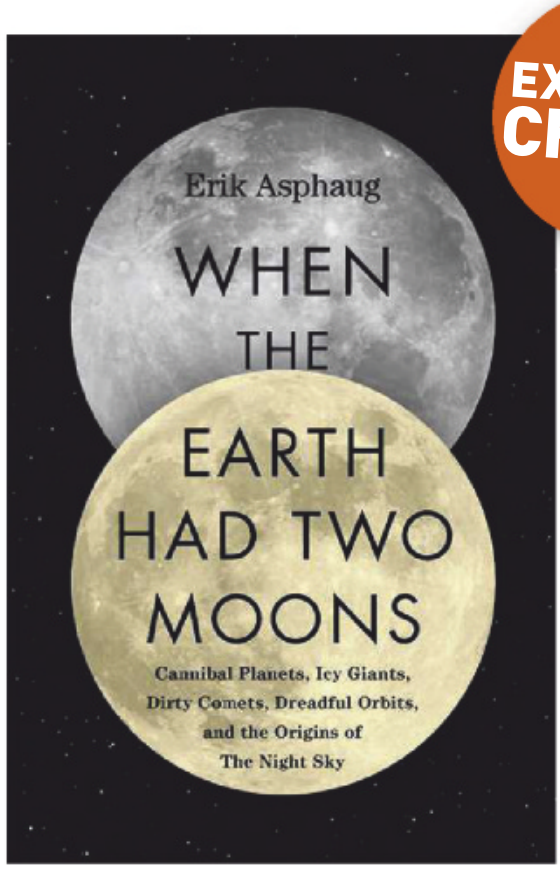


EXPERT'S CHOICE

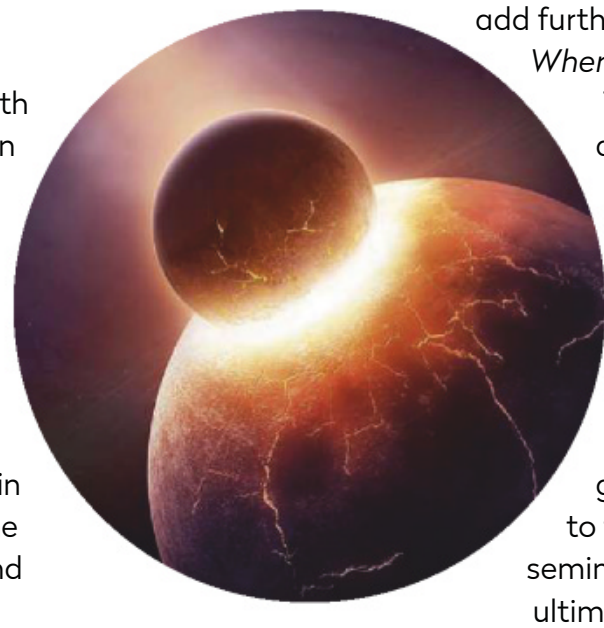
When the Earth had Two Moons

Erik Asphaug
Harper Collins
£22 ● HB

Once upon a time, Earth did not have a Moon. In fact, our entire Solar System was a very different place to the one we know now. Instead of the eight planets (or nine if you're a Pluto fan and stubborn like me) in stable orbits around the Sun with their weird and wonderful variety of satellites and a sprinkling of smaller asteroids and comets, a giant game of snooker was playing out. Large bodies on unstable orbits thanks to migrating giants (Jupiter, Saturn, Uranus and Neptune) were crossing paths and smashing into one another, some resulting in both bodies losing mass, others resulting in one body accreting a large portion of the other.

It is this latter type of impact between early Earth and a Mars-sized body, which we now call Theia, that is thought to have formed our very own Moon – and for a time perhaps more than one moon. In *When the Earth had Two Moons* Erik Asphaug takes us on a journey, both through time and space, providing a detailed overview of how this theory developed, what influence it has had on our understanding of the origin of other Solar System bodies (and vice versa) and our search for similar, perhaps life-bearing systems around other stars. Along the way we are given some great descriptions of the planets and some of their most striking satellites, as well as several asteroids, comets and Kuiper Belt objects, highlighting their often stark differences and contemplating conditions both at and below their surfaces.

A nice variety of illustrations complements the text and the book is peppered with analogies and footnotes to help the reader understand or just add further interesting asides. *When the Earth had Two Moons* is also interspersed with personal stories, from describing the field trip that awakened Asphaug's appreciation of geological timescales, to the 'brown bag' seminar he attended that ultimately led him to model the Earth-Theia impact event. The result is a book that goes beyond a statement of fact to bring you an engaging, insightful and, at times, thought provoking read. ★★★★★



▲ In the early days of the Solar System impacts between large bodies were frequent

JOHAN63/ISTOCK/GETTY IMAGES

***Dr Penny Wozniakiewicz** is a senior lecturer in Space Science at the University of Kent*

Interview with the author Erik Asphaug

Just how different are the two sides of the Moon?

While the near side is mottled with basaltic plains interspersed with highlands, the far side is nothing but highlands, 50–60km thick. These are like the Tibetan Plateau on Earth, except instead of being the result of plate tectonics they formed by the accumulation of anorthosite, the kind of rock that geochemists predict would crystallize and float to the top of a magma ocean losing its heat. Today's far side is mostly highlands, with no appreciable geology other than the pummelling of asteroid impacts over four billion years.

Is it a shame our Moon is not more active?

We can dream of being orbited by a more spectacular satellite. How about Titan? At night we'd see a 'planet' in the sky with clouds, storms and glints of lakes. But Titan formed in the cold of Saturn, so water is a continental rock, and methane and propane precipitate as rain. What about Io? A satellite the size of the Moon, where we would watch volcanoes erupting. But Io gets its heat from tidal flexing of orbiting Jupiter. Earth is too puny to do this.

Does the idea of human geologists on the Moon excite you?

The cost of a continuously inhabited base on the Moon, tens of billions a year shared among nations, would be a pittance compared to the historic symbolism. We're in need of such a turning point, and the path forward seems clear: robotic missions to explore the sites, then autonomous landings of the base components, followed by human researchers.

***Erik Asphaug** is a planetary scientist at the Lunar & Planetary Laboratory, University of Arizona*

The Cosmic Revolutionary's Handbook

Luke Barnes, Geraint Lewis
Cambridge University Press
£17.99 ● HB

Are you unhappy with the state of cosmology and think it needs to be revolutionised? If so, cosmologists Luke Barnes and Geraint Lewis have written *The Cosmic Revolutionary's Handbook* just for you. The inspiration will be familiar to many an astronomer or cosmologist: letters from people who think they have a new theory to explain the Universe, but who can't get the details (or the maths) right.

The book starts with a comprehensive explanation of how theories are developed and evidenced by new observations – or how observations are explained by new theories. From a thorough consideration of Olbers' Paradox ("Why is the sky dark?"), to observations of the expanding Universe and its composition, the focus is on the Universe's origin and evolution.

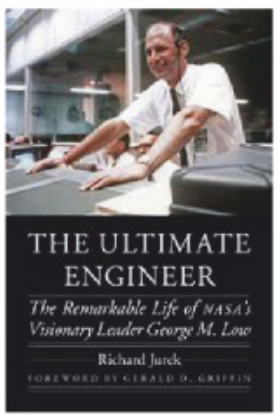
The text is at a level that a scientifically literate reader could easily understand. It would help to be comfortable with scientific notation and experimental uncertainties (ie, error bars); while these are explained they are fairly central to many of the arguments.

The more subtle aspects of cosmology are complicated and uninitiated readers may struggle. However, the book would be a great starting point for budding astronomers or cosmologists who want to be able to 'debunk' would-be revolutionaries – or answer the "but how do we know..." they're likely to get asked. ★★★★☆

***Dr Chris North** is Odgen Science Lecturer and STFC Public Engagement Fellow at Cardiff University*

The Ultimate Engineer: The Remarkable Life of NASA's Visionary Leader George M Low

Richard Jurek
University of Nebraska Press
£26.99 ● HB



Of all 400,000 people who made the Apollo programme happen, this latest spaceflight history argues that George M Low – Apollo Spacecraft Program Chief – was the most essential. An aeronautical engineer at NASA's predecessor organisation, Low was in the right place at the right time to help plan the US space programme, proposing the Moon as a long-term objective, a suggestion that was seized upon by President Kennedy.

Low went on to make that achievement possible. When three astronauts died during a launch pad test of Apollo 1 in 1967, he led a rigorous redesign, implementing thousands of improvements. The following year he championed leapfrogging Apollo 8 into lunar orbit, which essentially won the Space Race with Russia.

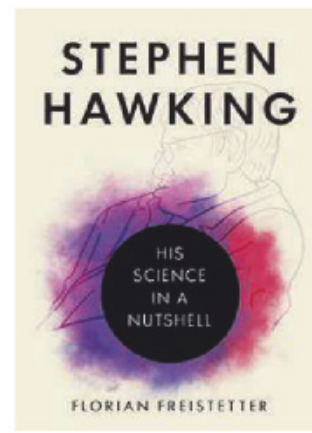
In the 1970s Low saved NASA from abolition, shepherding the Space Shuttle to approval, keeping NASA in business and making the International Space Station possible. Dying tragically young at 58, his dream of flying aboard the Shuttle went unfulfilled, although he did live to see his son, G David Low, selected as an astronaut.

Learning English as a second language as an Austrian immigrant, Low chose words with forensic rigour, helping him win technical and political arguments. His family fled the Nazis, opening the question of how he got on with V-2 and Saturn V designer Wernher von Braun. Some allege there was tension between the two – von Braun blamed Low for his 1970s reassignment to NASA HQ – but none of that is present here: a curious omission in a highly readable book that features plenty of eyewitness accounts. ★★★★☆

***Sean Blair** writes for the European Space Agency website*

Stephen Hawking: His Science in a Nutshell

Florian Freistetter
Prometheus Books
£15.99 ● HB



At the beginning of this book, the author tells of his first encounter with Stephen Hawking's book *A Brief History of Time* and that he (a complete novice to natural sciences at the time) understood only a fraction of its contents. It did, however, manage to inspire him to go on to study astronomy.

The aim of this book is to make some of Hawking's most important work more understandable. It is Hawking's *The Universe in a Nutshell* in a nutshell, if you will. It covers his work on singularities with respect to black holes as well as at the beginning of the Universe. It also covers gravitational waves, event horizons, the information paradox, Euclidean space-time and Hawking radiation. Relativity and quantum mechanics are explored, along with imaginary numbers and imaginary time.

There are some very clear and simple diagrams, though perhaps not enough of them, and some of the explanations and analogies work better than others. The writing is often not as clear as it could be, and when things get more complicated key ideas are sometimes glossed over. Some prior knowledge is assumed, and I would have liked more basic principles to have been introduced as a grounding for the heavier science.

At the end of the book, the author acknowledges that Hawking was uniquely skilled at communicating the complexities of his work to the general public, and I would agree. Which rather begs the question whether a book seeking to make his work more accessible is really necessary. ★★☆☆☆

***Jenny Winder** is a freelance science writer, astronomer and broadcaster*

Elizabeth Pearson rounds up the latest astronomical accessories

GEAR

1 Omegon angled finder scope eyepiece

Price £85 • **Supplier** Telescope House
Tel 01342 837098 • **www.telescopehouse.com**

You'll no longer need to crouch to look through your polar finder scope. The angled eyepiece puts your viewing position at 90° to the drawtube without disturbing the image orientation, allowing for a more comfortable observing experience.

2 Belka and Strelka pin badge

Price £8 • **Supplier** Etsy • **www.etsy.com**

This enamel pin depicts space dogs Belka and Strelka, the first two living creatures to travel to space and return. The design shows the pair orbiting over a glittering globe. Created and sold by StinkyInkyShop and InkedPaws.

3 Moon jigsaw

Price £15.99 • **Supplier** Royal Museums Greenwich
https://shop.rmg.co.uk

Can you tell your Tycho crater from your Copernicus? Challenge your knowledge of the lunar surface by assembling this circular 100-piece puzzle of a high-resolution image of the full Moon, taken from NASA's archives.

4 Men's Halcon jacket

Price £350 • **Supplier** Páramo
Tel 01892 786444 • **www.paramo-clothing.com**

This jacket has nine sizeable and well-placed pockets, allowing you to hold all your eyepieces and accessories. The special fabric uses directional technology to wick away moisture from the skin, helping you to stay warm. A woman's version, the Alondra, is also available.

5 Push-to passive tracking

Price £201.55 • **Supplier** Geoptik
Tel +39 045 925 0989 • **www.geoptik.com**

This device attaches to your Dobsonian telescope, allowing you to keep track of its position with a planetarium app, helping you find your way around the night sky. Currently only compatible with SkySafari.

6 Celestron 1.25" Moon filter set

Price £42 • **Supplier** The Widescreen Centre
Tel 01353 776199 • **www.widescreen-centre.co.uk**

These lunar filters help you prevent straining your eyes by eliminating the glare from our celestial neighbour. This set has three neutral density filters to reduce brightness and an additional filter to emphasise the contrast of lunar features.

Shaoni Bhattacharya interviews Daniel Eisenstein

Q&A WITH A DARK ENERGY HUNTER

As the Dark Energy Spectroscopic Instrument (DESI) fires up its 5,000 robotic 'eyes', scientists hope to unravel cosmology's greatest mysteries

What will DESI investigate about dark energy?
We don't know what dark energy is. The goal of DESI is to investigate the cause of the Universe's accelerating expansion rate, commonly ascribed to dark energy pushing things apart. DESI will try to measure this rate more accurately so we can get a better understanding of the kind of dark energy theories that could help explain observations.

How will DESI do this?
DESI's primary task is to measure the redshift of galaxies. As the Universe expands, the wavelength of the light from distant objects is stretched – this is called the cosmological redshift.

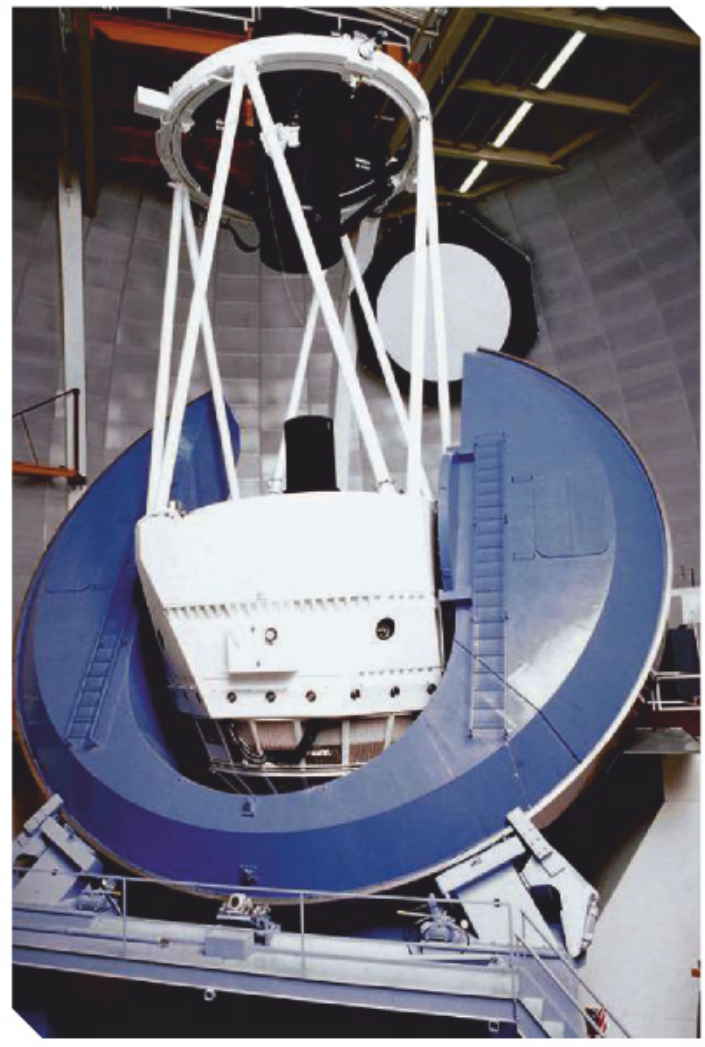
It's hard to measure distances when you look at galaxies – you are not easily able to see whether it's a big galaxy far away or a little galaxy nearby – but distance and redshift are tightly related. When you measure redshift you are turning a 2D picture of the sky into a 3D map.

The problem is that you don't know the intrinsic scale. When you look at a road map there's a key, and it turns out nature has imprinted a very hard-to-detect scale bar in the map of galaxies. DESI is designed to measure enough galaxies and make a big enough map that we can actually tease out this subtle signal which gives the scale. Once you have this you can figure out how far away the galaxies truly are.

How will DESI map the sky?
DESI makes maps by measuring the spectra of millions of galaxies. Each spectrum is taken from the light of a particular galaxy, which is spread out into a rainbow, and then we can measure the thousands of different colours.

There are characteristic frequencies that galaxies emit more or less light at. You measure these spectra and see that these frequencies are shifted from where they are measured in the laboratory, and that gives the redshift of the galaxy.

How many galaxies do you hope to look at?
The goal is to map 35 million galaxies. DESI will look at 5,000 targets at once – it has the biggest current observational capacity and will be a big improvement over the previous surveys that have observed a few million galaxies.



▲ **DESI is being prepared for the huge Mayall Telescope at Kitt Peak, shown here**

Professor Daniel Eisenstein is based at Harvard-Smithsonian and is co-spokesperson for DESI. He is a professor of astronomy at Harvard University

What is the instrument itself like?
DESI is built for the 4-metre Mayall Telescope at Arizona's Kitt Peak National Observatory. It has a series of six lenses that bring light into a sharp focus over a large field of view. Once the light goes through to the focal plane you have 5,000 robotic positioners moving small fibre optic cables into the right position. This means that the light from a distant galaxy enters the fibre and bounces down to the spectrograph.

What's the schedule for the project?
DESI had its 'first light' in October 2019 and we are now testing the instrument and making sure all the parts can work together, which will take till early spring. The main five-year survey will start in autumn 2020.

We will be able to start analysis after the first year of data – we will have a map large enough to produce interesting cosmological analyses. We are hoping to have the results out in 2022.

What do you hope will be the outcome from DESI and how will it help us to improve our understanding of the Universe?
The primary product from DESI will be the largest 3D map of the Universe yet made, which is exciting. It will be used for a wide range of science applications.

But specifically, the question we are trying to answer most is about the cosmological constant. This dates back to Einstein and is the idea that empty space is filled with some small but non-zero vacuum energy. If that energy's there and if gravity responds to it, it creates the effect of a cosmological constant and a small acceleration of the expansion of the Universe.

Another way of phrasing the question is – is the cosmological constant really constant? I think that is the central question raised by DESI. It's about whether the Universe we can measure is really consistent with the model of a cosmological constant.

NOAO/AURA/NSF, DAMIEN JEMISON

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

View the Winter Hexagon, the night sky's brightest asterism, and Gemini's mythical twins

When to use this chart

1 Feb at 24:00 AEDT (13:00 UT)
15 Feb at 23:00 AEDT (12:00 UT)
29 Feb at 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

FEBRUARY HIGHLIGHTS

February's evenings find the largest and most impressive asterism of stars standing on the northern horizon, the Winter Hexagon. Starting with Sirius, near the zenith, proceed anticlockwise to Rigel, then Aldebaran and onto the lowest member, Capella, just above the horizon. The shape is completed by the twins (Castor and Pollux) and Procyon. The hexagon is the brightest asterism, encompassing seven of the 20 brightest stars in the heavens.

STARS AND CONSTELLATIONS

The mythical twins of Gemini were called Castor and Pollux. In this constellation these names are used for Gemini's two brightest stars, which also mark the position of their heads. This couple is associated with the mythology of the ship Argo Navis – the ancient southern constellation now divided into Carina, Vela and Puppis. The twins accompanied Jason on his search for the Golden Fleece, whose origin is also immortalised in the heavens as Aries the Ram.

THE PLANETS

Venus continues being the evening star and hard to ignore in the early western sky. For the first half of February, Mercury can be found deeper in the twilight glare (20° to the lower left of Venus), before dropping into solar conjunction by the month's end. Uranus needs to be caught early as it's setting mid-evening. The morning is busy with Mars visible around 02:00, followed by Jupiter then Saturn, the three making an alignment near the Teapot of Sagittarius in the predawn eastern sky.

DEEP-SKY OBJECTS

The region near the feet of the Gemini twins contains some impressive open star clusters, such as M35 (NGC 2168, RA 6h 08.9m, dec. +24° 20'). Located about 3° northwest of the naked-eye pair of stars, Mu and Eta Geminorum, this 5th magnitude open cluster is composed of around 100 stars in an area of about 0.5° across. The stars vary in brightness and appear haphazardly scattered, with the fainter outer members blending into the surrounding star field. See how some of the prominent stars form curved lines and find an east–west, star-starved band dissecting M35 – it's a very attractive sight.

A low power eyepiece shows another cluster in the same field as M35 (0.4° southwest), NGC 2158. A 15–20cm instrument shows this 8th magnitude cluster as a 0.1° diameter glowing cloud, while larger scopes reveal a collection of faint stars.

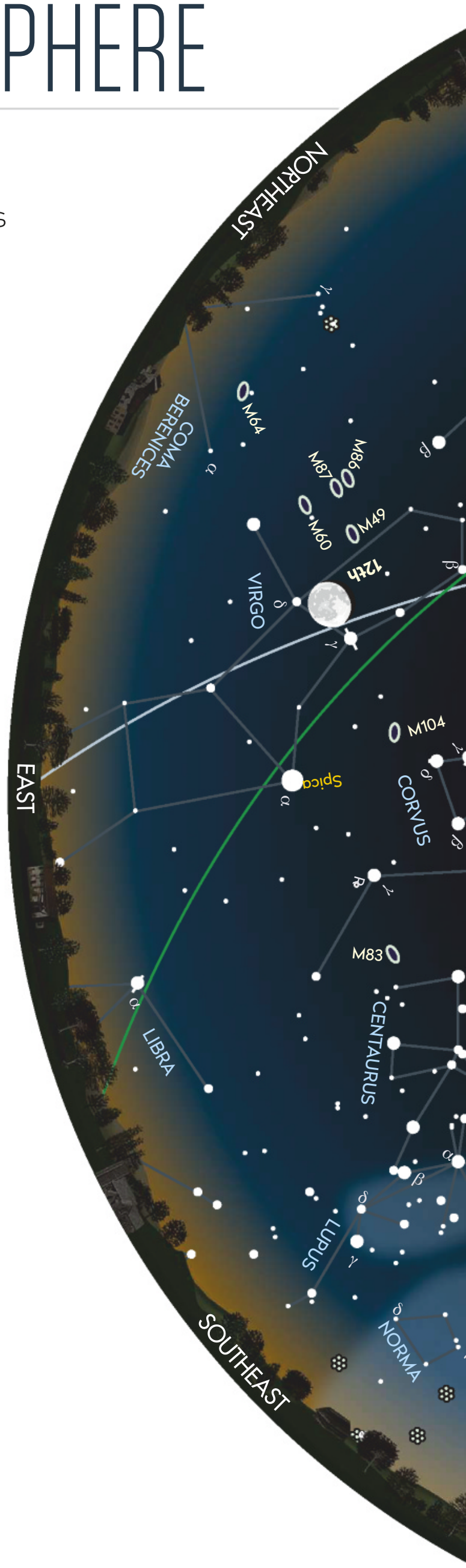

Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
Celestial Equator
Ecliptic
Winter Hexagon
Winter Triangle
Mirror of Venus
False Cross
South Celestial Pole
Eta Carina Nebula
Tarantula Nebula
Rosette Nebula
Jewel Box
Coal Sack
Alpha Centaurids Peak 08 Feb
Ghost of Jupiter
Rigel Kent
w Cen
Sickle
NGC 2158
NGC 2397
LMC
SMC
61h
9th
3rd
Aldebaran
Betelgeuse
Rigel
Sirius
Procyon
Castor
Pollux
Regulus
Alphard
Hadar
Acrux
Canopus
Achernar
Menkar
Hyades
M44 Beehive
URSA MAJOR
LYNX
LEO MINOR
LEO
CANCER
GEMINI
AURIGA
ANDROMEDA
Attach
CANIS MINOR
ORION
TAURUS
HYDRA
MONOCEROS
CANIS MAJOR
LEPUS
PUPPIS
PYXIS
ANTLIA
CRATER
VELA
CARINA
COLUMBA
PICTOR
CAELUM
PUPPIS
VOLANS
DORADO
RETICULUM
HOROLOGIUM
FORNAX
ERIDANUS
CETUS
MUSCA
CHAMAELEON
MENSA
CIRCINUS
TRIANGULUM AUSTRALE
APUS
OCTANS
HYDRUS
PHOENIX
NGC 300
ARA
PAVO
TUCANA
CRUX
M35
M36
M37
M78
M43
M42
M41
M50
M47
M48
M46
M93